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Behavioural interventions to promote workers' use of respiratory protective equipment (Review)

Luong Thanh BY, Laopaiboon M, Koh D, Sakunkoo P, Moe H

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[Intervention Review]

Behavioural interventions to promote workers' use of respiratory protective equipment

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ABSTRACT

Background

Respiratory hazards are common in the workplace. Depending on the hazard and exposure, the health consequences may include: mild to life-threatening illnesses from infectious agents, acute effects ranging from respiratory irritation to chronic lung conditions, or even cancer from exposure to chemicals or toxins. Use of respiratory protective equipment (RPE) is an important preventive measure in many occupational settings. RPE only offers protection when worn properly, when removed safely and when it is either replaced or maintained regularly. The effectiveness of behavioural interventions either directed at employers or organisations or directed at individual workers to promote RPE use in workers remains an important unanswered question.

Objectives

To assess the effects of any behavioural intervention either directed at organisations or at individual workers on observed or self-reported RPE use in workers when compared to no intervention or an alternative intervention.

Search methods

We searched the Cochrane Work Group Specialised Register, the Cochrane Central Register of Controlled Trials (CENTRAL 2016, Issue 07), MEDLINE (1980 to 12 August 2016), EMBASE (1980 to 20 August 2016) and CINAHL (1980 to 12 August 2016).

Selection criteria

We included randomised controlled trials (RCTs), controlled before and after (CBA) studies and interrupted time-series (ITS) comparing behavioural interventions versus no intervention or any other behavioural intervention to promote RPE use in workers.

Data collection and analysis

Four authors independently selected relevant studies, assessed risk of bias and extracted data. We contacted investigators to clarify information. We pooled outcome data from included studies where the studies were sufficiently similar.

Main results

We included 14 studies that evaluated the effect of training and education on RPE use, which involved 2052 participants. The included studies had been conducted with farm, healthcare, production line, office and coke oven workers as well as nursing students and people with mixed occupations. All included studies reported the effects of interventions as use of RPE, as correct use of RPE or as indirect measures of RPE use. We did not find any studies where the intervention was delivered and assessed at the whole organization level or in which the main focus was on positive or negative incentives. We rated the quality of the evidence for all comparisons as low to very low.

Training versus no training

One CBA study in healthcare workers compared training with and without a fit test to no intervention. The study found that the rate of properly fitting respirators was not considerably different in the workers who had received training with a fit test (RR 1.17, 95% Confidence Interval (CI) 0.97 to 1.10) or training without a fit test (RR 1.16, 95% CI 0.95 to 1.42) compared to those who had no training. Two RCTs that evaluated training did not contribute to the analyses because of lack of data.

Conventional training plus additions versus conventional training alone

One cluster-randomised trial compared conventional training plus RPE demonstration versus training alone and reported no significant difference in appropriate use of RPE between the two groups (RR 1.41, 95% CI 0.96 to 2.07).

One RCT compared interactive training with passive training, with an information screen, and an information book. The mean RPE performance score for the active group was not different from that of the passive group (MD 2.10, 95% CI -0.76 to 4.96). However, the active group scored significantly higher than the book group (MD 4.20, 95% CI 0.89 to 7.51) and the screen group (MD 7.00, 95% CI 4.06 to 9.94).

One RCT compared computer-simulation training with conventional personal protective equipment (PPE) training but reported only results for donning and doffing full-body PPE.

Education versus no education

One RCT found that a multifaceted educational intervention increased the use of RPE (risk ratio (RR) 1.69, 95% CI 1.10 to 2.58) at three years' follow-up when compared to no intervention. However, there was no difference between intervention and control at one year's, two years' or four years' follow-up. Two RCTs did not report enough data to be included in the analysis.

Four CBA studies evaluated the effectiveness of education interventions and found no effect on the frequency or correctness of RPE use, except in one study for the use of an N95 mask (RR 4.56, 95% CI 1.84 to 11.33, 1 CBA) in workers.

Motivational interviewing versus traditional lectures

One CBA study found that participants given motivational group interviewing-based safety education scored higher on a checklist measuring PPE use (MD 2.95, 95% CI 1.93 to 3.97) than control workers given traditional educational sessions.

Authors' conclusions

There is very low quality evidence that behavioural interventions, namely education and training, do not have a considerable effect on the frequency or correctness of RPE use in workers. There were no studies on incentives or organisation level interventions. The included studies had methodological limitations and we therefore need further large RCTs with clearer methodology in terms of randomised sequence generation, allocation concealment and assessor blinding, in order to evaluate the effectiveness of behavioural interventions for improving the use of RPE at both organisational and individual levels. In addition, further studies should consider some of the barriers to the successful use of RPE, such as experience of health risk, types of RPE and the employer's attitude to RPE use.

PLAIN LANGUAGE SUMMARY

Ways to encourage workers to wear protective equipment to stop them breathing in harmful substances

It is common at many workplaces for the air to contain substances that are harmful to health. These may include bacteria and viruses, various fumes and smoke, and dusts and particles such as asbestos or grain. Depending on what and how much of it is inhaled, the health consequences may vary from mild to life-threatening. These consequences range from feelings of irritation to short- and long-term illness including cancer. In many work settings respiratory protective equipment (RPE) is used to prevent workers from inhaling harmful substances. Various ways have been introduced to teach workers how to use RPE effectively. However it is unclear how well they work. Therefore, we wanted to find out if there are interventions that can encourage workers to use RPE correctly or more often.

Studies found

We searched for relevant research studies up to 20 August 2016. We found 14 studies that analysed the effectiveness of behavioural interventions to promote RPE use. We also located one ongoing study. Studies had been conducted with 2052 farm, healthcare, production line, office and coke oven workers as well as nursing students and people with mixed occupations. We did not find any studies where the researchers conducted and assessed an intervention at the level of a whole organization.

What the research says

All included studies compared different education and training interventions to encourage workers to use RPE correctly or more often. We found very low quality evidence that behavioural interventions such as education and training do not increase the number of workers that use RPE or that use RPE correctly.

What is the bottom line

We conclude that there is low to very low quality evidence that behavioural interventions do not encourage workers to use RPE correctly or more often. It is likely that our conclusions will change when new studies are published. We need better quality studies that look at the effectiveness of different types of interventions. These interventions should be targeted at both individuals and organisations, to improve effective RPE use. In addition, further studies should consider some of the barriers to the successful use of RPE, such as experience of health risk, types of RPE and the employer's attitude to RPE use.

SUMMARY OF FINDINGS

Summary of findings for the main comparison. Training versus no intervention

Training versus no intervention

Patient or population: Healthcare workers
Settings: Veterans Affairs hospital, USA
Intervention: Training

Control: No intervention

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	No intervention	Training				
Properly fitting RPE at 6 months follow-up (with fit testing)	**806 per 1000**	**944 per 1000** (782 to 1000)	**RR 1.17** (0.97 to 1.41)	83 (1 study)	⊕⊖⊖⊖ **very low[1]**	One Controlled Before After (CBA) study ¤
Properly fitting RPE at 6 months follow-up (without fit testing)	**781 per 1000**	**906 per 1000** (742 to 1000)	**RR 1.16** (0.95 to 1.42)	96 (1 study)	⊕⊖⊖⊖ **very low[1]**	One CBA-study ¤

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: Confidence interval;

¤ Two studies Myers 1995; Or 2012 did not report enough data to be included in the analysis.

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[1] Starting at low quality, we downgraded the quality of evidence with one level because of small sample size. We would have downgraded the quality of evidence with one more level due to study limitations (only 1 CBA study with high risk of selection bias) but we had already reached very low quality. We found no reason to upgrade the quality of evidence.

Summary of findings 2. Conventional training plus additions versus conventional training

Conventional training plus fit test versus conventional training

Patient or population: Health workers
Settings: Healthcare institutes
Intervention: Conventional training plus additions

Control: Conventional training

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Conventional training	Conventional training plus additions				
Observed appropriate RPE use	**531 per 1000**	**749 per 1000** (510 to 1000)	**RR 1.41** (0.96 to 2.07)	64 (1 study)	⊕⊖⊖⊖ **very low** [1]	One cluster-RCT
Correct use of RPE as part of full-body PPE **- Donning**	The mean correct use of RPE as part of full-body PPE - donning in the control groups was **14.56 score**	The mean correct use of RPE as part of full-body PPE - donning in the intervention groups was **0.52 higher** (0.14 to 0.9 higher)		50 (1 study)	⊕⊖⊖⊖ **very low** [2]	One RCT
Correct use of RPE as part of full-body PPE **- Doffing**	The mean correct use of RPE as part of full-body PPE - doffing in the control groups was **18.32 score**	The mean correct use of RPE as part of full-body PPE - doffing in the intervention groups was **1.16 higher** (0.7 to 1.62 higher)		50 (1 study)	⊕⊖⊖⊖ **very low** [2]	One RCT

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: Confidence interval; **RR:** Risk ratio;

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[1] We downgraded the quality of evidence from high quality with one level because of very small sample size, with one level due to study limitations (unclear risk of bias for sequence generation and allocation concealment) and with one more level due to imprecision (a wide confidence interval for the RR).

[2] We downgraded the quality of evidence from high quality with one level because of very small sample size, with one level due to study limitations (unclear risk of bias for sequence generation, allocation concealment and detection bias) and with one more level due to indirect outcome (RPE measured as a part of PPE).

Summary of findings 3. Education versus no intervention

Education versus no intervention

Patient or population: Workers
Settings: Developed and developing countries
Intervention: Educatiion

Control: No intervention

Outcomes[#]	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	No intervention	Education				
Use of RPE most of the time - 3 years after intervention	**282 per 1000**	**476 per 1000** (310 to 727)	**RR 1.69** (1.1 to 2.58)	170 (1 study)	⊕⊕⊖⊖ **low** [1]	One RCT
Reported RPE use among farmers - Short term follow-up (6 weeks)	**875 per 1000**	**936 per 1000** (796 to 1000)	**RR 1.07** (0.91 to 1.26)	105 (1 study)	⊕⊖⊖⊖ **very low** [2]	One CBA
Reported RPE use among farmers - Long term follow up (6 months - 1 year)	**734 per 1000**	**727 per 1000** (617 to 859)	**RR 0.99** (0.84 to 1.17)	206 (2 studies)	⊕⊖⊖⊖ **very low[3]**	Two CBAs
Use of safety mask while working	**190 per 1000**	**390 per 1000** (141 to 1000)	**RR 2.05** (0.74 to 5.69)	44 (1 study)	⊕⊖⊖⊖ **very low** [4]	One CBA
Fit tested for N95	**217 per 1000**	**70 per 1000** (15 to 324)	**RR 0.32** (0.07 to 1.49)	52 (1 study)	⊕⊖⊖⊖ **very low** [3]	One CBA
Use of N95 mask	**174 per 1000**	**793 per 1000** (320 to 1000)	**RR 4.56** (1.84 to 11.33)	52 (1 study)	⊕⊖⊖⊖ **very low** [3]	One CBA

[#] For each study, when more RPE use outcomes were reported, we selected the RPE use outcome with the most reliable information; two studies (Parkinson 1989, Perry 2003) did not report enough information to be included.

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: Confidence interval; **RR:** Risk ratio;

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[1] We downgraded the quality of evidence from high quality with one level because of study limitations (unclear risk of bias for sequence generation and allocation concealment, and high risk of bias for attrition bias) and with one level due to imprecision (a wide confidence interval for the RR).
[2] Starting at low quality, we downgraded the quality of evidence to very low level because of study limitations (CBA study; high risk of bias for sequence generation, allocation concealment and detection bias) and small sample size.
[3] Starting at low quality, we downgraded the quality of evidence to very low level because of study limitations (CBA study; high risk of bias for sequence generation, allocation concealment and detection bias) and imprecision (a wide confidence interval for the RR).
[4] Starting at low quality, we downgraded the quality of evidence to very low level because of study limitations (CBA study; high risk of bias for sequence generation, allocation concealment and detection bias) and very small sample size.

Summary of findings 4. Motivational interview-based education versus traditional lectures

Motivational interview-based education versus traditional lectures

Patient or population: Factory workers
Settings: Iran
Intervention: Motivational interview-based education

Control: Traditional lectures

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Traditional lectures	Motivational interview-based education				
Use of RPE as part of full-body PPE (score on checklist)	The mean use of PPE in the control groups was **8.22**	The mean use of PPE in the intervention groups was **2.95 points higher** (1.93 to 3.97 higher)		70 (1 study)	⊕⊖⊖⊖ **very low** [1]	One CBA

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: Confidence interval;

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[1] Starting at low quality, we downgraded the quality of evidence with one level because of imprecision due to very small sample size and a wide confidence interval for the MD. We would have downgraded the quality of evidence with one more level due to study limitations (unclear risk of bias for sequence generation and allocation concealment) but we had already reached very low quality. We found no reason to upgrade the quality of evidence.

BACKGROUND

The use of respiratory protective equipment (RPE) is an important preventive measure in many occupational settings. However, RPE only offers protection when worn properly, when removed safely and when it is either replaced or maintained regularly (Nicholson 2015).

Description of the condition

Respiratory hazards are common in the workplace. These hazards include biological agents, such as organisms that cause tuberculosis or influenza, vapours such as diisocyanates and welding fumes, and dusts and particles such as asbestos or grain. Respiratory hazards occur in a wide variety of occupations, including nursing, farming, construction, mining or work in the manufacturing industry.

Depending on the hazard and exposure, the health consequences may include mild to life-threatening illnesses from infectious agents, acute effects ranging from respiratory irritation to chronic lung conditions, or cancer from exposure to chemicals or toxins.

For a workplace to be considered to have a significant inhalation hazard, employees must have been exposed to a respiratory hazard greater than a stipulated standard, such as the threshold limit value (TLV), as established by the American Conference of Governmental Industrial Hygienists (ACGIH) (Hubbard 2000).

Based on the so-called hierarchy of controls, employers should first try to eliminate, substitute or control the inhalation hazards through engineering controls (e.g. enhanced ventilation, isolation of equipment and products) (Ellenbecker 1996). If these are not feasible then administrative controls can be used (e.g. limiting exposure time by rotation of employees, limiting exposure time in set-up, final process or maintenance). RPE can be an additional intervention or sometimes the last line of defence.

RPE may also be used as an interim control measure because it is not immediately practical to implement some measures (such as engineering controls) when these hazards are present. In other situations RPE use may be appropriate when accessing a contaminated area for a short period, or when maintenance operations need to be carried out. In addition, RPE may need to be worn in some emergency situations.

In practice, the use of RPE is often favoured by employers because it is generally a cheaper option when compared to the cost of controlling the hazard at its source. In 2005, 40,002 private sector establishments were surveyed, having been randomly selected from 174,305 private sector establishments among 50 states or the District of Columbia of the United States (Doney 2005). Agricultural establishments employing 10 or fewer workers were excluded from this study. Doney 2005 found that RPE use was required in 4.5% of establishments and for 3.1% of employees. The US Occupational Safety & Health Administration (OSHA) respiratory protection standard covers an estimated five million respirator wearers working in an estimated 1.3 million workplaces in the covered sectors (OSHA 1998). The major limitation of RPE is that the anticipated protection is achieved only if the equipment is worn correctly. In addition, RPE performance in the workplace is generally much poorer than is suggested by standards or manufacturers' literature (Howie 2005).

Description of the intervention

It is not possible to control exposure by simply providing RPE to workers. RPE can only be effective if used as part of a more comprehensive programme (Szeinuk 2000). Howie 2005 gives the following definition of an RPE programme that should only be used after all technically possible controls have been implemented:

- workers who still need respiratory protection should be identified;
- workers should be informed of the consequences of exposure to ensure that they correctly understand the importance of wearing respiratory protection;
- the correct protective equipment, which can adequately control residual exposure, should be selected;
- the protective equipment should be matched to the wearer on an individual basis and with fit tests. It should be ensured that when more protective equipment is used at the same time, they are mutually compatible and that there are no other risks created (e.g. impairment of the visual field);
- the wearer should be trained and supervised;
- efforts should be made to minimise wearing times and equipment should be maintained in an efficient and hygienic condition;
- there should be a monitoring programme to ensure continuing effectiveness of the respiratory protection programme.

In many countries there are legal requirements for the use of respiratory protection that make one or more of these elements mandatory (OSHA 1998). For example, see Directive 89/656/EEC 1989 on the use of personal protective equipment (PPE), of which RPE use is an integral part.

Many workplaces where RPE is used do not have a written programme to determine the type of respirator to use. In addition, in many workplaces staff either do not know RPE is required, or employees are not assessed for medical fitness to wear RPE (Han 2009). In more than 20% of workplaces surveyed in the United States, staff were unaware of whether air sampling was performed for respiratory hazards to which the workers were exposed, respirator training was not provided for workers and programme administrators had not received respirator training (Greskevitch 2007). Training is essential because proper functioning depends to a great extent on wearing the equipment correctly (Howie 2005).

There are also distinct barriers to the use of RPE. A study of firefighters in the United States reported that lack of funding (48%) and lack of understanding (39%) were the greatest barriers to programme implementation (Easterling 2007). Salazar 2001 describes the factors that had the most positive influence on respirator use, which were concern about work exposure, fit test and training, while the factors that were the most negative influences were communication, personal comfort, effect on vision, structural environment and fatigue.

Other studies have reported the benefit of various types of RPE to prevent the intake of various hazardous substances into the body via inhalation, but many of these studies do not address the personal behaviour of the workers and their actual use of RPE while they are at work (Malo 1992; Oguss 2010; Syamlal 2007; Vigo 2005).

How the intervention might work

The purpose of RPE is to prevent the inhalation of harmful airborne substances or to provide a source of breathable air when breathing in oxygen-deficient atmospheres. This is achieved in workplaces by means of training, fit testing and supervision of the correct wearing of RPE, including all the programme elements mentioned above.

RPE programmes can be implemented at several levels. The first is implementation of a programme at a national level. In many countries there is legislation in place that makes it mandatory for employers to have such a programme under certain conditions. Compliance with legislation can be voluntary, enhanced by incentives such as money or prizes/awards for the best complying organisations or enforced by agencies such as a Labour Inspectorate.

At the company level, policies and employer support for RPE programmes can be encouraged by incentives and disincentives.

At the individual level, it is often the individual worker's behaviour that determines whether RPE is maintained, worn and worn correctly. Individual RPE compliance is a multi-component, behavioural process. Various factors affect RPE use at different stages of compliance, for example workers' perception of risks, ease of use and how comfortable or uncomfortable it is to use the RPE. These are potential leverage points.

Training is important but needs to go beyond basic knowledge. Facilitating or enabling the conditions and workplace climate enhance the transfer of training and are important for day-to-day ongoing compliance.

Why it is important to do this review

Lunt 2011 reviewed the effects of behavioural interventions for dermal and respiratory hazards but the interventions reviewed were focused on a wider array of behaviour than just RPE use. Furthermore, they did not use Cochrane methods for their review. There are no systematic reviews of the effectiveness of behavioural interventions that are either directed at organisations or directed at individual workers to promote RPE use in workers. Consequently this remains an important unanswered question.

OBJECTIVES

To assess the effects of any behavioural intervention either directed at organisations or at individual workers on observed or self-reported RPE use in workers when compared to no intervention or an alternative intervention.

METHODS

Criteria for considering studies for this review

Types of studies

We included randomised controlled trials (RCTs). We included trials where the intervention was assigned either to individual participants or clusters of participants.

It is difficult to randomise in a work organisation. Therefore we also included non-randomised studies. We considered the following non-RCT study designs for inclusion: controlled trials without randomisation, such as controlled before and after (CBA) studies where the outcome was measured before and after the intervention, and interrupted time-series (ITS), which refers to multiple observations of the outcome over time that were 'interrupted' by an intervention or treatment.

In future updates of this review, we will include ITS studies that have at least three data points before and three data points after the interrupting intervention (EPOC 2006; Ramsay 2003).

Types of participants

Workers exposed to respiratory hazards that require RPE use.

Types of interventions

- Behavioural interventions directed at organisations aiming to implement RPE programmes.

We categorised these interventions as:

  - legislation and enforcement;
  - incentives, as in money or positive feedback; and
  - information and guidance.
- Behavioural interventions directed at workers for promoting RPE use.

We categorised these interventions as:

  - information, education and training;
  - incentives, as in money or positive feedback;
  - sanctions and negative feedback.

We compared any intervention with alternative interventions or no intervention.

Types of outcome measures

Primary outcomes

- For organisations: proper implementation of all elements of an RPE programme.
- For workers: appropriate use of RPE. We studied both short-term behavioural outcomes immediately after the intervention and long-term behavioural outcomes more than six months after the intervention. We considered both self-reports and observations of RPE use as equally valid. We made a distinction between the measurement of using RPE as such and properly fitting RPE and reported these as separate outcomes.

Secondary outcomes

- Degree to which barriers to RPE use had been overcome.
- Degree to which RPE use hinders normal functioning at work.

We only included studies if they had measured our primary outcome criteria and we use only the primary outcomes for drawing conclusions about the effectiveness of the interventions.

Search methods for identification of studies

Electronic searches

We searched the following databases: CENTRAL (first in 2013, Issue 11 and last in 2016 Issue 07), which includes the Cochrane Work Group Specialised Register of trials, MEDLINE (1980 to August 12,2016), EMBASE (1980 to August 20,2016) and CINAHL (1980

to August 12, 2016). We also searched Dissertation Abstracts to identify additional studies on respiratory protection that may not necessarily appear in the published literature. There were no restrictions on language, date or place of publication.

The search strategy we used for MEDLINE through PubMed is included as Appendix 1. We developed search strategies for the other databases based on the MEDLINE strategy. We present the search strategies for the other databases as Appendix 2, Appendix 3 and Appendix 4.

We also wanted to find non-randomised studies. Therefore we did not apply a study design filter but we only used search strings for RPE and work.

Searching other resources

We scrutinised the reference lists of identified study reports for additional citations. We contacted specialists in the subject area about unpublished data.

Data collection and analysis

The methodology for data collection and analysis is based on the *Cochrane Handbook of Systematic Reviews of Interventions* (Higgins 2011).

Selection of studies

Four authors (YT, HM, PS and DK) independently screened references identified by the systematic searches to identify articles that would fulfil our inclusion criteria. Where there was disagreement or doubt, we retrieved the full article. These same four authors (YT, HM, PS and DK) independently assessed the full study report to see if it met the review inclusion criteria. We consulted the remaining review author (ML) in cases of unresolved disagreement. Then, based on full-text assessment, we included all studies that fulfilled the inclusion criteria as described above in Criteria for considering studies for this review.

Data extraction and management

Four authors (YT, HM, PS and ML) independently extracted data about the methods, participants, interventions, outcomes and main results of the included trials using a data collection form. WE consulted the fifth author (DK) in cases of unresolved disagreement. Where necessary, we contacted the trial authors directly to complete data forms or clarify methodology. We entered the extracted data into the Cochrane statistical software, Review Manager (RevMan 2014), and checked them for accuracy.

Assessment of risk of bias in included studies

Four review authors (YT, HM, DK and ML) independently conducted 'Risk of bias' assessment of all the included studies by adapting the procedures described for the six domains in the Cochrane Handbook for Systematic Reviews of Interventions (Higgins 2011): random sequence generation, allocation concealment, blinding of outcome assessors, incomplete outcome data, selective reporting and other potential sources of bias. We graded each study for risk of bias in each domain, with ratings of low risk of bias, high risk of bias or uncertain risk of bias.

We judged a study to have a low overall risk of bias when we judged that all of the aforementioned criteria were at low risk of bias. Conversely, we considered a study to have a high overall risk of bias if we judged that any of the aforementioned criteria were at high or unclear risk of bias.

We resolved disagreements by discussion.

If we include any interrupted time-series (ITS) studies in future updates of this review, we will assess their risk of bias with the criteria developed by the Cochrane Effective Practice and Organisation of Care (EPOC) Group (EPOC 2006).

The quality assessment for ITS designs consists of:

- protection against secular changes (three items);
- protection against detection bias (two items);
- completeness of data set (one item); and
- reliable primary outcome measures (one item).

We will answer each item as 'done', not clear' or 'not done'.

Measures of treatment effect

We plotted the results of each RCT as point estimates, such as risk ratios (RRs), indicating change in binary outcomes such as appropriate use of RPE (yes/no), and means and standard deviations (SDs) for continuous outcomes such as frequency of appropriate use of RPE.

For controlled studies with baseline differences and continuous outcome measures, we took the changes between baseline and follow-up as the measure of treatment effect. With dichotomous outcome measures we plotted both the outcomes at baseline and at follow-up as rate ratios.

If we include any ITS studies in future updates of this review, we will extract data from the original papers when available and re-analyse them according to the recommended methods for analysing ITS designs for inclusion in systematic reviews (Ramsay 2003).

Unit of analysis issues

We included studies where individual workers were randomised and also cluster-randomised studies (CRT) where, for example, workplaces were the unit of randomisation. For studies that employed a cluster-randomised design but did not make an allowance for the design effect we calculated the design effect based on a fairly large assumed intra-cluster correlation of 0.10. We based this assumption by analogy on studies about implementation research (Campbell 2000; Ukoumunne 1999). We followed the methods in the *Cochrane Handbook for Systematic Reviews of Interventions* for these calculations (Higgins 2011).

Dealing with missing data

We contacted authors to obtain missing data from their reports that were needed for meta-analysis. We received data from Perry 2003. In the updates of this review, if statistics are missing, such as standard deviations or correlation coefficients, we will calculate them from other available statistics such as P values according to the methods in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011).

Assessment of heterogeneity

We assessed clinical homogeneity based on similarity of population, intervention, outcome and follow-up (Verbeek 2012).

We considered interventions to be similar if they fell into one of the pre-defined categories of interventions (as stated in Criteria for considering studies for this review) and had similar content. We made a distinction between education only and education that included demonstration and fitting of RPE because we expected that demonstration and fitting would increase the effect of instruction. We added another category that we described as multifaceted interventions, which combined elements of the various intervention types.

We considered a no intervention control group different from one in which a minor intervention was applied.

We regarded the outcomes use of RPE and the correctness of the fit of RPE to be different and we did not combine them. We regarded follow-up times of less than three months, three months to one year and more than one year as different.

We regarded healthcare workers exposed to tuberculosis bacteria as being different from farm workers exposed to organic dust and we did not combine these studies.

If we can pool studies in future updates of this review, we will test for statistical heterogeneity by means of the Chi^2 test as implemented in the forest plot in RevMan 2014. We will use a significance level of P value < 0.10 to indicate whether there is a problem with heterogeneity. Moreover, we will quantify the degree of heterogeneity using the I^2 statistic, where an I^2 value of 25% to 50% indicates a low degree of heterogeneity, 50% to 75% a moderate degree of heterogeneity and > 75% a high degree of heterogeneity (Higgins 2003).

Assessment of reporting biases

We prevented reporting bias by including studies and not publications in order to avoid the introduction of duplicate data (i.e. two articles could represent duplicate publications of the same study). Following the Cho 2000 statement on redundant publications, we attempted to detect duplicate studies and, if more articles had reported on the same study, we would have extracted the data only once. We prevented location bias by searching across multiple databases. We prevented language bias by not excluding articles based on language. As we did not have more than five studies to include in a single comparison, we did not assess publication bias by using a funnel plot.

Data synthesis

We pooled studies that were sufficiently similar with RevMan 5.3 software (RevMan 2014). When studies were not statistically heterogeneous we used a fixed-effect model.

GRADE and 'Summary of findings'

We used the GRADE approach as described in the *Cochrane Handbook for Systematic Reviews of Interventions,* using the GRADEPro 3.2 software to present the quality of evidence in a 'Summary of findings' table (GRADEpro 2008; Higgins 2011).

The downgrading of the quality of a body of evidence for a specific outcome is based on five factors:

- study limitations;
- indirectness of evidence;
- inconsistency of results;
- imprecision of results;
- publication bias.

The GRADE approach specifies four levels of quality (high, moderate, low and very low).

We report the findings for the four training and education intervention categories and the primary outcomes in four summary of findings tables. We do not report the secondary outcomes there because studies using these outcomes form only a subset of all available studies, as per our inclusion criteria.

Subgroup analysis and investigation of heterogeneity

We did not conduct subgroup analysis as there were so few studies to include. In the future updates of this review we will carry out subgroup analyses for the primary outcomes. If sufficient data are available, we will conduct the subgroup analyses according to the following factors:

- type of work: different sectors of work (e.g. health care, farming);
- category of behavioural interventions (e.g. training versus behaviour-based safety versus organisational-level (safety climate/culture interventions));
- types of RPE: full versus partial RPE;
- gender;
- high versus low exposure area.

Sensitivity analysis

We would have carried out sensitivity analysis to explore the effect of study risk of bias but there were too few studies available per comparison.

RESULTS

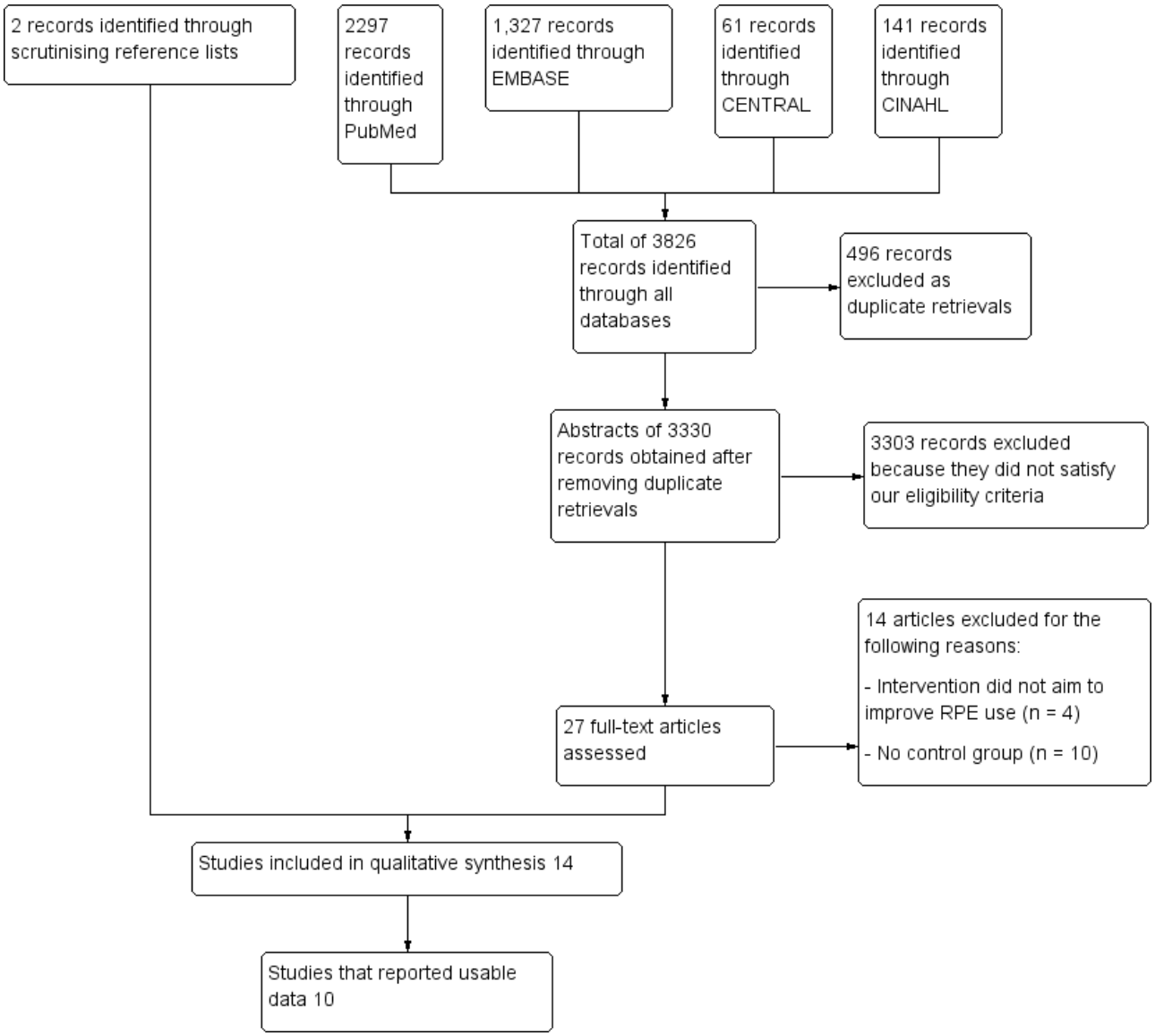
Description of studies

See: Characteristics of included studies; Characteristics of excluded studies.

Results of the search

We conducted our systematic search in December 2013 and again in August 2016. We identified 3826 records from four databases (CENTRAL, PubMed, EMBASE, CINAHL). After excluding 496 duplicate records, we were left with 3330 records for screening of titles and abstracts according to the eligibility criteria. We conducted additional searches in Dissertation Abstracts but there were no studies that satisfied our inclusion criteria. Screening of all the de-duplicated records produced only 27 potentially eligible studies to retrieve as full-text articles that we considered for inclusion. We also checked the reference lists of these potential included studies and found no further potential studies to include. We identified two further potential studies from a systematic review addressing a topic related to our review (Lunt 2011). Having read all 29 full-text articles, we excluded 14 studies. Finally, we included 14 studies in this review that satisfied our inclusion criteria. In addition, we located one ongoing study. See Figure 1 for a PRISMA study flow diagram showing a detailed account of the search and study inclusion process.

Figure 1. PRISMA flow chart of study selection procedure



Included studies

We included 14 studies. One study is still ongoing (Chen 2016) and we present it in Characteristics of ongoing studies. Full details of the other 14 studies are presented in the Characteristics of included studies table.

Design of the studies

Of the 14 published studies, eight were RCTs (Carrico 2007; Donham 2011; Eckerman 2002; Hung 2015; Myers 1995; Or 2012; Parkinson 1989; Perry 2003), and six were CBA studies (Dressel 2007; Gjerde 1991; Hannum 1996; Kim 2012; Navidian 2015; Shamsi 2015).

Carrico 2007 randomised healthcare workers but measured the use of RPE at the patient level and therefore there was clustering at the healthcare worker level. We considered this to be a cluster-randomised trial. We therefore adjusted for the clustering effect according to the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011). We adjusted the results for the clustering based on a calculated design effect (1+ (4.2-1)*0.1 = 1.32). We used this design effect as a correction factor for dividing the events and the number of participants. The average cluster size of 4.2 was based on a total of 84 observations for the 20 nurses studied. The intra-cluster correlation (ICC) of 0.1 is a conservative estimate based on analogy with implementation interventions and taken from Campbell 2000. Even though farms were randomised in Donham 2011, there was only one participant per farm and we did not consider this a cluster-randomised trial. Parkinson 1989 used a cluster-randomised design comparing workers randomly chosen from seven intervention plants with workers randomly chosen from control plants. The intervention was randomly assigned to the intervention plant group. There was no adjustment for the clustering effect. However, because the authors did not report sufficient data we could not calculate an adjusted effect estimate.

The included CBA studies used a variety of intervention and control groups. Gjerde 1991 conducted an educational intervention study with swine confinement producers in Iowa. The swine confinement

workers from seven southeastern counties were designated as the educational intervention (or treatment) group. Workers from seven northeastern counties served as the non-intervention (or control) group. Hannum 1996 conducted a trial with two intervention groups of individual and group training and a control group without training. Dressel 2007 compared an intervention group consisting of farmers with a control group, where they simply stated that they "did not participate". It is unclear if these were farmers that were not willing to participate in the intervention or if there were other reasons for non-participation.

Study settings and time

Eight studies were carried out in the USA. The other six studies were conducted outside the USA: one in Canada (Kim 2012), one in Germany (Dressel 2007), two in Iran (Navidian 2015; Shamsi 2015), and two in Hong Kong (Hung 2015; Or 2012). The publication dates of the studies spanned 23 years, with one in the 1980s (Parkinson 1989), and three in the 1990s (Gjerde 1991; Hannum 1996; Myers 1995). Ten studies were carried out after 2000 (Carrico 2007; Donham 2011; Dressel 2007; Eckerman 2002; Hung 2015; Kim 2012; Navidian 2015; Or 2012; Perry 2003; Shamsi 2015).

Participants and duration of studies

Altogether the 14 included studies involved 2052 participants.

Four studies involved healthcare workers (Carrico 2007; Hannum 1996; Hung 2015; Or 2012). The healthcare workers were 20 emergency department registered nurses in Carrico 2007, 179 healthcare workers employed in a 775-bed Veterans' Affairs hospital in Hannum 1996, 50 registered nurses, enrolled nurses and healthcare assistants in Hung 2015 and 84 first-year undergraduate nursing students in Or 2012. Follow-up time was three months (from January to March 2005) in Carrico 2007 and two years in Hannum 1996, but it was unclear at what time during follow-up the outcome was measured. Different follow-up times were found in Hung 2015 (one week for the control group and two weeks for the intervention group). Or 2012 provided unclear information on follow-up time.

Five studies involved farm workers (Donham 2011; Dressel 2007; Gjerde 1991; Kim 2012; Perry 2003). Donham 2011 included various farms (308). Dressel 2007 evaluated the effects of the intervention in 105 farmers with occupational asthma. Gjerde 1991 studied 209 swine confinement workers, Kim 2012 involved 68 farmers and Perry 2003 studied 400 Wisconsin dairy farmers certified to apply pesticides to field crops over a one-year evaluation period. Follow-up times in theses studies varied from one month to four years.

Five studies involved other types of workers (Eckerman 2002; Myers 1995; Navidian 2015; Parkinson 1989; Shamsi 2015). Eckerman 2002 involved 123 adults recruited through advertisements in local newspapers, the website of the Oregon Health and Science University and flyers distributed at a liberal arts university. Myers 1995 studied 64 white-collar workers who were not engaged in the research, design or manufacture of RPE and were inexperienced in RPE use. Navidian 2015 studied 70 workers at glass production facilities. Parkinson 1989 involved 328 coke oven workers from seven pairs of coke plants, matched regarding geographic location, work force size and ethnic composition. Shamsi 2015 involved 44 construction workers building subway stations. Follow-up times in these studies varied from three days to six months.

Types of intervention and comparison groups

Interventions directed at organisations

We did not find any studies where the intervention was delivered and assessed at the whole company level. We had expected to find studies that had evaluated the effectiveness of legislation and enforcement, incentives such as money or positive feedback, or information and guidance. However, we found no such studies.

Interventions directed at workers

All 14 included studies evaluated only training and education interventions. Following the example of Cheetham 2016, we defined training as the imparting or shared practice of skills and education as the imparting or shared creation of knowledge. When it comes to learning how to use RPE, training involves participants handling the equipment themselves, which means putting it on, taking it off and adjusting it. We classified six studies as training interventions. Education on the other hand involves class lectures or presentations, group-based instruction or other types of information delivery such as leaflets and self-learning packages. We classified the remaining eight included studies as education interventions. We present the details of each intervention in Table 1. We present the results of training and education interventions separately in the four following comparisons.

1. Training versus no intervention

There were only two studies comparing training with no intervention (Hannum 1996; Or 2012). In the Hannum 1996 study the intervention groups received one-on-one training by the hospital hygienist and the respirators were fit tested. Another group received group instruction on the ward, and the third group received no formal training. The control group had none of these interventions. In Or 2012, there were three educational groups: group A was trained in fit check procedure and fit test performance, group B did not perform fit test but was trained in fit check procedure, and group C received fit test performance but no training in fit check procedure. Group D served as a control group with no fit test performed and was not trained to perform the fit check.

2. Conventional training plus additions versus conventional training alone

There were four studies comparing conventional training plus additions with conventional training alone (Carrico 2007; Eckerman 2002; Hung 2015; Myers 1995). In the Carrico 2007 study, the intervention group received supplemental training in addition to classroom training, using visual demonstration of respiration particle dispersion involving the use of a patient bio-simulator. The control group received standard classroom teaching. Eckerman 2002 had four groups of intervention: programmed instruction (PI) active, PI passive, INFO-book (reading information from a book, non-interactive) and INFO-screen (reading information on a computer screen, non-interactive). The intervention provided basic respiratory protection information and addressed the following: uses (preventing symptoms), limitations (immediately dangerous to life or health conditions, seal, fit tests), and maintenance of air-purifying and supplied air respirators (valve, cartridge replacement); recognition of respiratory hazards (lead, solvents, carbon monoxide; acute and chronic effects); selection of proper respirators for different hazards (material safety data sheets, product labels, permissible exposure limits) and measurement

of hazard levels. In Hung 2015 the intervention group received conventional personal PPE training plus computer-simulated training using the proposed simulation program - web-based interactive software with a user-friendly graphical interface for users to practise the use of PPE via dragging and dropping various PPE onto a virtual healthcare worker and by responding to multiple choice questions online. The control group received conventional PPE training only. In Myers 1995 the intervention group was trained to don the RPE with the aid of a fit check, while the control group was trained to don the RPE without conducting a fit check.

3. Education versus no intervention

There were seven studies comparing education with no intervention (Donham 2011; Dressel 2007; Gjerde 1991; Kim 2012; Parkinson 1989; Perry 2003; Shamsi 2015). The Donham 2011 study employed a multifaceted intervention that included medical screening, education, on-farm safety audits with set safety standards and performance incentives. A USD 200 monetary incentive was given to participants if they had more than 85% compliance on an audit score including RPE use. The intervention was given to the principal operator of the farm. The control group received no intervention. Dressel 2007 used two sessions that lasted four to five hours to explain the causes and prevention of occupational asthma and to demonstrate the use of respirators. In the Gjerde 1991 study, the participants in the intervention group received a series of six educational home study modules and were invited to attend one of three evening sessions in which respirator use and gas measurement were demonstrated. The control group was reported as non-intervention without any further details. Kim 2012 provided one evening of education on work-related asthma and agricultural causes; spirometry testing; respirator demonstrations and fit testing; exposure reduction strategies; and barriers to personal protective equipment (PPE) use, whereas the control group received no intervention. Parkinson 1989 used four sessions during a two-year period with information about the occupational safety and health work of the unions, cancer risk at the coke plant, the Occupational Safety & Health Administration (OSHA) coke oven standard and the content of the control programme at each plant. The control group received no intervention. Shamsi 2015 distributed a free package containing a well-designed, light-weight helmet, a dust mask, safety gloves and a simple tailored pamphlet about the advantages of using PPE and the risks they can reduce to the intervention group. A sticker with an emotionally tailored message reminding participants of the importance of caring for themselves because of their families was attached to the helmet. The control group received no intervention. In the study by Perry 2003, the intervention group received three hours of education sessions targeting four messages, including (1) existing evidence of excess cancers among farmers; (2) simulation of pesticide exposure presented through a slide show and description; (3) feedback on self-reported data collected from the farmers to date, and (4) cognitive behavioural strategies that could be adopted to reduce pesticide hazards and ultimately cancer risks. The intervention also included a training component that gave participants the opportunity to try on RPE, practice a brief check to make sure that all parts of the body were covered, and timing each other to illustrate how one can gear up properly in only a few minutes. In effect, the intervention contained both education and training components but education formed the bulk. The control group attended the standard re-certification meeting. The education sessions were given in groups ranging between 20 and 50 applicators (the term used by the study authors to denote participants).

4. Motivational interview-based education versus traditional lectures

Navidian 2015 gave the intervention group four educational sessions based on motivational interviewing, which were conducted in four groups of eight to 10 participants. Participants in the control group attended four one-hour safety education sessions given in the form of traditional lectures.

Sanctions

We found no studies that evaluated the effectiveness of sanctions, such as fines or negative feedback on RPE use.

Types of outcome measures

There were basically two types of eligible outcome measures: use of RPE and the correct use of RPE as measured by a fit test. The included studies reported results on either of these outcomes as follows:

Use of RPE

In the Carrico 2007 study the outcome of interest was the use of PPE including self-use of the mask and placement of the mask on the patient as observed by two trained observers. The specific type of RPE was a N95 respirator. We measured the RPE outcome from the self-use of the mask and placement of the mask. Donham 2011 measured self-reported respirator use at baseline and at one, two and three years of follow-up. Dressel 2007 measured RPE used. However, the specific type of RPE in this study was head gear. Gjerde 1991 presented self-reported use of an appropriate dust mask or some type of respirator when working at baseline and one year later using a questionnaire. Kim 2012 reported the use of PPE, including reported mask use, use of a N95 mask, fit-testing for N95, use of respirator (powered air purifying respirator), and use of mask while brushing animals. These outcomes were related to RPE. Parkinson 1989 used 'wearing respirator always' to indicate RPE use. Shamsi 2015 measured self-reported use of PPE, including the use of helmet, safety mask, safety gloves and safety shoes while working. We considered using a safety mask while working to be RPE use.

Correct use of RPE

Hannum 1996 reported the correct use of RPE as measured by passing a respirator fit test administered by nurses at six months after the intervention. Myers 1995 measured successful RPE donning tested over three days immediately after training. The authors measured the quality of each donning from measurements of particle concentrations inside and outside the respirator during a chamber test. Or 2012 measured respirator fit continuously for a period of 15 minutes.

Three included studies measured RPE use as part of full-body protection (PPE) use (Hung 2015; Navidian 2015; Perry 2003) and we could not separate RPE use from PPE use. Hung 2015 reported mean scores of performance in PPE donning and doffing at pre- and post-intervention. An N95 respirator was a part of the PPE but its specific appropriate use data were not reported. Navidian 2015 reported the safety awareness, attitude and performance on the use of PPE. The authors measured PPE performance at pre- and post-intervention with a checklist with seven items concerning the use of any suitable equipment with a respirator being one of

them. The authors did not report specific scores for RPE use. Perry 2003 measured self-reported compliance with full PPE including a respirator. However, we could not extract the specific information on respirator use from the PPE compliance outcome. We consider these three studies to yield indirect evidence of effectiveness regarding correct use of RPE.

One included study evaluated correct use of RPE in a fashion that we did not foresee in our protocol (Sakunkoo 2012), by measuring knowledge regarding the correct use of RPE Eckerman 2002. This is of course not the same as skill in actually using RPE. The authors reported performance scores for basic respiratory protection information measured by a quiz test that contained four-item multiple-choice questions. We consider this study providing indirect evidence of effectiveness regarding correct use of RPE.

Excluded studies

We excluded 14 studies (Adewoye 2014; Bailey 2010; Becker 2004; Casalino 2015; Contreras 2012; Crippa 2007; Fu 2013; Gershon 2009; Harber 2013; Harber 2014; Huaroto 2013; Jenkins 2007; Myong 2016; Woith 2015). Reasons for the exclusion of these studies are presented in the Characteristics of excluded studies table.

Risk of bias in included studies

We present our judgements about each risk of bias item as percentages across all included studies in Figure 2, whereas Figure 3 shows our judgements about each risk of bias item for each included study.

Figure 2. 'Risk of bias' graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

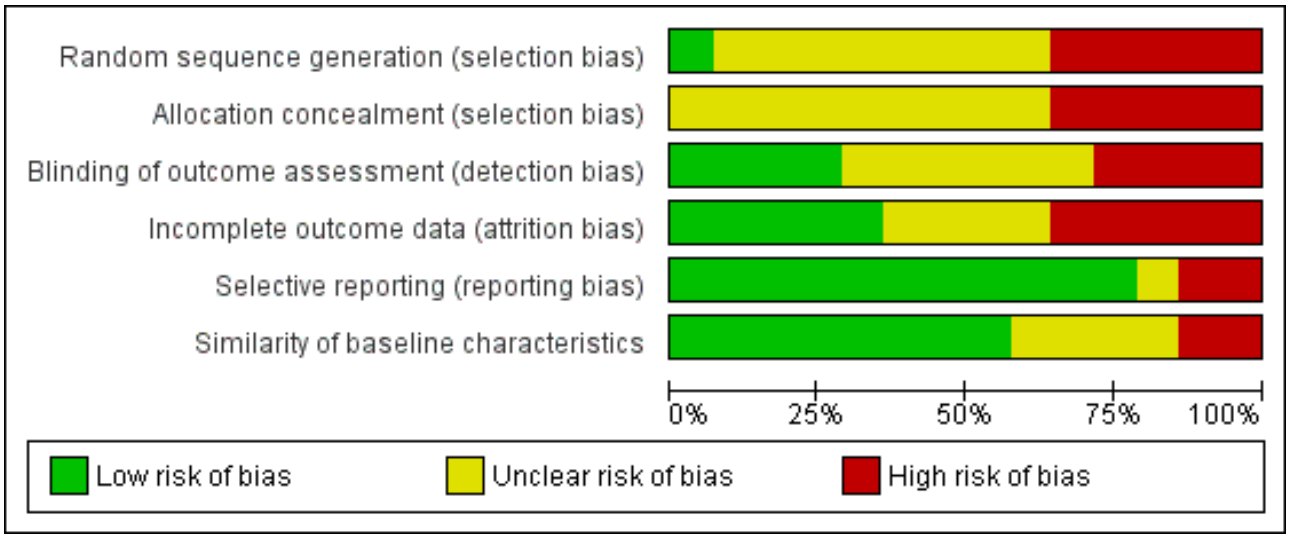
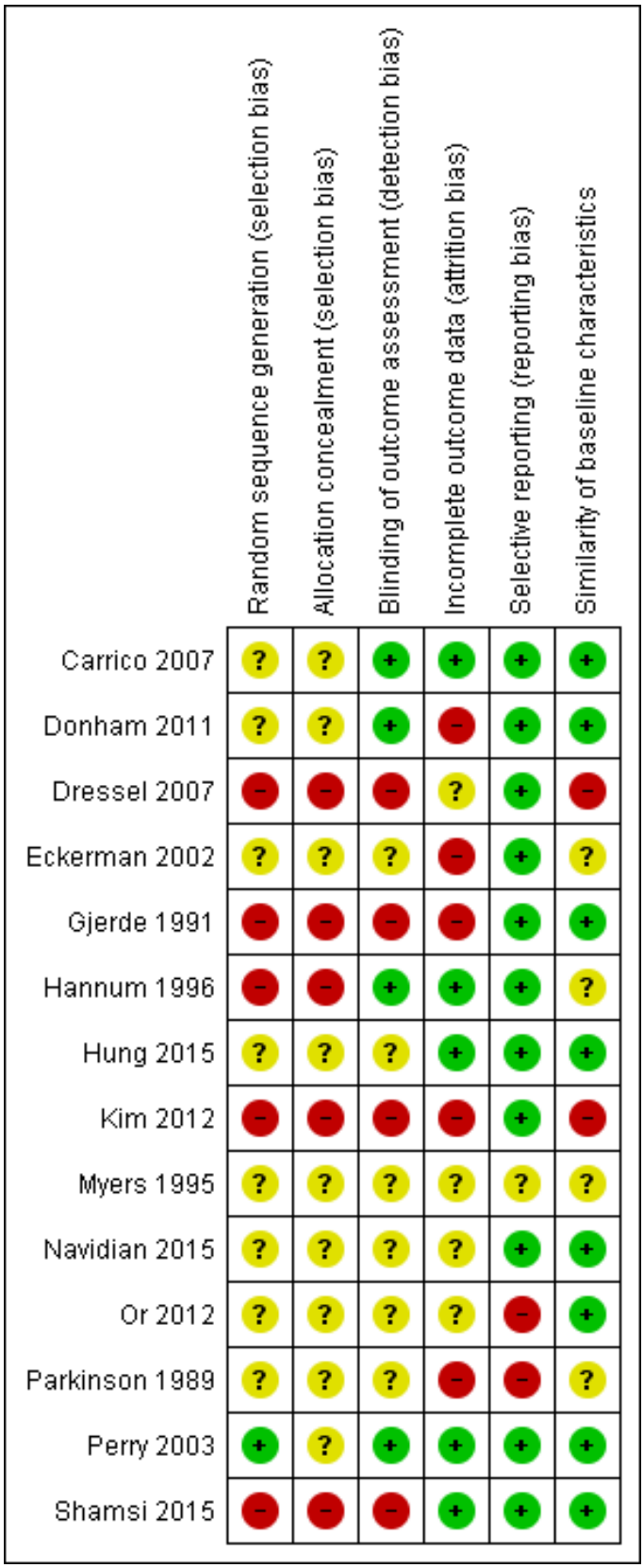


Figure 3. 'Risk of bias' summary: review authors' judgements about each risk of bias item for each included study.



Allocation

One RCT reported having used computer-generated allocation and therefore we judged it to have a low risk of bias for this item (Perry 2003). However, Perry 2003 did not describe allocation concealment and so we judged the study to have an unclear risk of bias for this item. The other eight included RCTs did not report their methods of sequence generation or allocation concealment (Carrico 2007; Donham 2011; Eckerman 2002; Hung 2015; Myers 1995; Navidian 2015; Or 2012; Parkinson 1989). Therefore, we judged the risk of selection bias to be unclear for these studies.

The other five trials were controlled before and after studies (Dressel 2007; Gjerde 1991; Hannum 1996; Kim 2012; Shamsi 2015). We assessed their potential for selection bias from the domain of similarity of baseline characteristics. Gjerde 1991 and Shamsi 2015 showed no significant differences in demographic characteristics of the intervention and control groups. We judged the risk of selection bias to be low. Hannum 1996 reported no information on baseline characteristics. We judged the risk of selection bias to be unclear. Dressel 2007 and Kim 2012 both had substantial differences in their baseline characteristics and we judged them to be at high risk of selection bias.

Blinding

We only assessed blinding of outcome assessors because blinding of participants is not feasible for behavioural interventions. We found that outcome assessors were blinded in four studies (Carrico 2007; Donham 2011; Hannum 1996; Perry 2003). Therefore we judged them to have a low risk of bias for this item. Gjerde 1991, Dressel 2007, Kim 2012 and Shamsi 2015 reported using a self-administered questionnaire for outcome assessment. We therefore judged the risk of detection bias to be high. We judged the other six studiesto be at unclear risk as there was no information available on blinding (Eckerman 2002; Hung 2015; Myers 1995; Navidian 2015; Or 2012; Parkinson 1989).

Incomplete outcome data

We judged five studies to have a low risk of attrition bias (Carrico 2007; Hannum 1996; Hung 2015; Perry 2003; Shamsi 2015). Carrico 2007, Hannum 1996; Hung 2015 and Shamsi 2015 reported all outcome data in all recruited participants. Perry 2003 reported only 6% and 3% dropouts in the intervention and control groups, respectively.

We judged five studies to have a high risk of attrition bias because of high loss to follow-up overall or because participant attrition was not the same for intervention and control groups(Donham 2011; Eckerman 2002; Gjerde 1991; Kim 2012; Parkinson 1989). Donham 2011 recruited 308 farmers (150 CSF intervention farmers and 158 controls), but there were altogether 281 farmers (91.2%), meaning 141 CSF intervention farms and 140 controls in the analysis for respirator use at entry. Considerable numbers of farmers dropped out from the study every year. At the fourth year of follow-up results were reported only for 75 farmers (50.0%) in the CSF intervention group and 55 farmers (34.8%) in the control group. Eckerman 2002 reported 36% (44/123) overall loss to follow-up, which means that 13/32 dropped out from the PI active group, 11/32 dropped out from the PI passive group, 8/28 dropped out from the INFO-book group and 12/32 dropped out from the INFO-screen group. In Gjerde 1991, data appropriate for the chosen analyses were obtained from 49 out of 102 workers in the intervention group and 79 out of 107 workers in the control group. In that study, 75% and 67% of all workers in the intervention group provided useful information at baseline and at one-year follow-up, while in the control group 88% and 80% of all workers in the control group provided useful information at baseline and at one-year follow-up. Kim 2012 reported that 76% (29/38) of the intervention group and 77% of the control group completed the follow-up survey at six months after the intervention. Parkinson 1989 included 554 workers but analysed 68% of these and did not adjust for missing data.

In the remaining four studies information to judge attrition was insufficient and therefore we judged the studies to have an unclear risk of attrition bias.(Dressel 2007; Myers 1995; Navidian 2015; Or 2012).

Selective reporting

We judged 11 studies to have a low risk of reporting bias as they reported data for all the outcome measures they listed in their methods (Carrico 2007; Donham 2011; Dressel 2007; Eckerman 2002; Gjerde 1991; Hannum 1996; Hung 2015; Kim 2012; Navidian 2015; Perry 2003; Shamsi 2015). We judged two studies to have a high risk of reporting bias (Or 2012; Parkinson 1989). Or 2012 did not present the expected outcomes clearly and in Parkinson 1989 the authors did not report all the same data at follow-up as they did at baseline.

Other potential sources of bias

In Donham 2011, farms that achieved at least an 85% audit score were awarded Certified Safe Farm status and were considered to be in the intervention group. These farms were also given a small financial incentive.

The self-reporting of outcomes in Gjerde 1991, in which participants were volunteers selected from among those farms eligible to participate, may give rise to the risk of a social desirability bias.

Hannum 1996 mentioned that the project started with participants being taught by the industrial hygienist (Group A). They later introduced group teaching by nurses (Group B) when the progress of individual training was not quick enough for the hospital. Subsequently, these groups were qualitatively fit-tested, together with those remaining who had not received training (Group C). This ad hoc arrangement may have led to selection bias.

Overall risk of bias

None of the included studies had low risk of bias for all items, which was our criterion for determining low overall risk of bias per study (see Assessment of risk of bias in included studies). We judged only one RCT to come close in that it had a low risk of bias in all but one domain (allocation concealment) (Perry 2003). Consequently we judged all included studies to have a high overall risk of bias.

Effects of interventions

See: **Summary of findings for the main comparison** Training versus no intervention; **Summary of findings 2** Conventional training plus additions versus conventional training; **Summary of findings 3** Education versus no intervention; **Summary of findings 4** Motivational interview-based education versus traditional lectures

We could report results data only for the primary outcomes of use of respiratory protective equipment (RPE) and correct use of RPE from 13 of the included studies (Carrico 2007; Donham 2011; Dressel 2007; Gjerde 1991; Hannum 1996; Hung 2015; Kim 2012; Myers 1995; Navidian 2015; Or 2012; Parkinson 1989; Perry 2003; Shamsi 2015). Three of these reported the effect of their interventions on the correct use of full-body protective equipment of which RPE was just one part (Hung 2015; Navidian 2015; Perry 2003).

The single remaining study reported data for knowledge of the correct use of RPE, which we accepted as a proxy measure of correct use (Eckerman 2002).

Study results could be pooled for only one comparison containing two studies. Otherwise pooling of results was not possible because of large variation in the types of interventions. Consequently we present results for individual studies. None of the included studies reported results for any of our secondary outcomes.

Interventions directed at organisations

Legislation and enforcement

We did not find any studies that had evaluated the effectiveness of occupational safety and health legislation and its enforcement in improving RPE use among employees.

Incentives (as in money or positive feedback)

We did not find any studies that had evaluated the effectiveness of incentives, when given to companies to improve RPE use among employees.

Information and guidance

We did not find any studies that had evaluated the effectiveness of information and guidance when given to companies to improve RPE use among employees.

Interventions directed at workers

We classified the results of the 14 included studies into four comparisons covering the only two available interventions: training and education. We present the effects of interventions for each comparison as follows.

1. Training versus no intervention

Primary outcome: Correct use of RPE

A CBA study in healthcare workers reported the pass rate for fit tests that indicated properly fitting respirators. This did not significantly increase in the workers who had received either training with a fit test (RR 1.17; 95% Confidence Interval (CI) 0.97 to 1.10) or training without a fit test (RR 1.16; 95% CI 0.95 to 1.42) compared to those who had no training (Hannum 1996) (Analysis 1.1).

One RCT showed non-significant differences in mean scores for respirator performance between groups (A, B, C) trained in performing fit checks and an untrained group (D) (Or 2012). The authors report only ANOVA test results for individual tasks and not group scores. The authors did not respond to our requests to provide us their raw data so that we could verify their results.

One RCT found fewer unsuccessful donnings and more consistent donnings for both common types of RPE used in the intervention group compared to the control group (Myers 1995). However, we could not extract the reported numerical figures from their publication due to the complicated way in which the authors had measured and reported RPE use.

2. Conventional training plus additions versus conventional training

Primary outcome: Use of RPE

One cluster-randomised trial found that there was no difference in the appropriate use of RPE after adjustment for the clustering effect (RR 1.41, 95% CI 0.96 to 2.07) (Carrico 2007) (Analysis 2.1). The clustering effect was 1.32 as presented in Included studies ('Design of the studies').

Primary outcome: Correct use of RPE as part of full-body PPE

One RCT compared computer-simulation training with conventional personal protective equipment (PPE) training (Hung 2015). The study found that participants in the computer-simulation training group performed significantly better in both donning and doffing full-body PPE than those in the conventional PPE training group (Mean Difference (MD) 0.52, 95% CI 0.14 to 0.90; and MD 1.16, 95% CI 0.70 to 1.62, respectively; Analysis 2.2).

Knowledge of correct use of RPE as proxy of actual correct use

One RCT compared interactive training with passive training and with an information screen and an information book (Eckerman 2002). The mean RPE performance score for the Programmed Instruction (PI-active) group, who received interactive training, was not different from that of the PI-passive group (MD 2.10, 95% CI -0.76 to 4.96). However, the PI-active group scored significantly higher than the INFO-book group (MD 4.20, 95% CI 0.89 to 7.51) and the INFO-screen group (MD 7.00, 95% CI 4.06 to 9.94). On the other hand, the PI-passive group's score was not different from that of the INFO-book group (MD 2.10, 95% CI -1.23 to 5.43) but it was higher than that of the INFO-screen group (MD 4.90, 95% CI 1.94 to 7.86) (Analysis 2.3).

3. Education versus no intervention

Primary outcome: Use of RPE

One RCT compared a multifaceted educational intervention to a no intervention control and reported the use of RPE from one to four years after the initiation of the intervention (Donham 2011). A small increase in RPE use was seen in the intervention group in the follow-up years. However, a statistically significant difference in RPE use between the two groups was only found at three-year follow-up (risk ratio (RR) 1.69, 95% CI 1.10 to 2.58). There was no considerable difference between intervention and control at one year follow-up (RR 1.30, 95% CI 0.97 to 1.76), at two years' follow-up (RR 1.33, 95% CI 0.96 to 1.83) or at four years' follow-up (RR 1.15, 95% CI 0.76 to 1.76; Analysis 3.1).

Three controlled before and after (CBA) studies compared education interventions to no intervention and presented self-reported RPE use at short term follow-up of six weeks (Dressel 2007) and at long term follow-up of six months (Kim 2012) and one year (Gjerde 1991). There were no significant differences in reported RPE use between the two groups either at short term follow-up (RR 1.07, 95% CI 0.91 to 1.26) or long term follow-up (pooled RR 0.99, 95% CI 0.84 to 1.17; 206 farmers; 2 studies; Analysis 3.2).

One CBA by Shamsi 2015 compared providing participants a free package containing a well-designed, light-weight helmet, a dust mask, safety gloves and a simple tailored pamphlet about the advantages of using PPE and the risks they can reduce with no intervention. There was no significant difference in the frequency of RPE use between the intervention and control groups (RR 2.05, 95% CI 0.74 to 5.69; Analysis 3.3).

One CBA by Kim 2012 compared providing one evening of education on work-related asthma and agricultural causes; spirometry testing; respirator demonstrations and fit testing; exposure reduction strategies; and barriers to personal protective equipment (PPE) use with no intervention. There was no significant difference between intervention and control in the use of a respirator (PAPR) (RR 4.00, 95% CI 0.20 to 79.43; Analysis 3.4), or in conducting N95 respirator fit testing (RR 0.32, 95% CI 0.07 to 1.49; Analysis 3.5). However, participants in the intervention group were much more likely to use an N95 mask (RR 4.56, 95% CI 1.84 to 11.33; Analysis 3.6).

One RCT did not report sufficient data to be included in a meta-analysis but the authors reported a similar non-significant effect of the intervention on RPE use to the other studies, with an effect size of 0.05 and an F value of 0.43 (df = 143) (Parkinson 1989).

Primary outcome: Correct use of RPE as part of full-body PPE

One RCT compared a multifaceted educational intervention with a no intervention control and reported the use of RPE as part of full-body PPE (Perry 2003). The authors found no significant difference between the intervention and control groups in PPE use six months after the intervention (odds ratio (OR) 1.10, 95% CI 0.80 to 1.51). However, the authors did not report the figures on which their results are based. The authors also did not respond to our requests to provide us their raw data so that we could verify their results.

4. Motivational interview-based education versus traditional lectures

Primary outcome: Correct use of RPE as part of full-body PPE

One CBA compared motivational interviewing-based education and traditional lectures (Navidian 2015). The authors found that participants who underwent motivational group interviewing-based safety education scored higher on a checklist measuring PPE use (MD 2.95, 95% CI 1.93 to 3.97) than control workers who underwent traditional educational sessions (Analysis 4.1).

Quality of the evidence

We judged all studies to have a high risk of bias and therefore we downgraded the quality of the evidence by one level for all comparisons. All but one comparison had only a single study and therefore we did not downgrade the quality of the evidence for inconsistency nor publication bias for these comparisons. None of the comparisons had more than 400 participants and all but one study had a wide confidence interval including 1, and therefore the possibility of a considerable harmful or beneficial effect. Therefore we downgraded the quality of the evidence by one level for all comparisons due to imprecision. We considered four studies to yield indirect evidence, which would have been sufficient reason to downgrade the level of evidence with one level in two comparisons because of indirectness. But there was no need for this as we had already dowgraded the quality of evidence in both of these comparisons to very low.

For the controlled before and after studies, we found no reason to upgrade the quality of the evidence.

DISCUSSION

Summary of main results

We included in this Cochrane review 14 published studies involving 2052 participants. We also identified one ongoing study. The interventions in these included studies were only in the education and training category. We did not find any studies evaluating organisational interventions, or incentives (either monetary or positive feedback) or disincentives (either sanctions or negative feedback).

There is very low quality evidence provided by three RCTs and five CBA studies that behavioural interventions, namely education and training, do not have an effect on the frequency or correctness of RPE use in workers. There is low quality evidence provided by one RCT that an educational intervention increased the use of RPE at three years' follow-up when compared to no intervention. However, in the same study there was no difference between intervention and control at one year's, two years' or four years' follow-up. There is very low quality evidence from one RCT that training leads to fewer unsuccessful donnings and more consistent donnings but we could not verify this because of unclearly reported results. There is also inconsistent very low quality evidence provided by two RCTs and one CBA study about the effect of education and training interventions on the use of respiratory protective equipment (RPE) as part of full-body personal protective equipment. Finally, there is very low quality evidence from one RCT that interactive training can improve knowledge of the correct use of RPE.

Overall completeness and applicability of evidence

Included studies had evaluated different types of RPE and results were mainly from self-reported assessment. It is apparent from the studies included in our Cochrane review that the provision of advice does not help in the use of RPE. The included studies also lacked significant information on the degree to which barriers to the use RPE while working could affect the results (e.g. types of RPE used at work or the attitude of workers when using RPE). This limits the usefulness and applicability of the results.

Moreover, most studies were conducted in developed countries, mainly in the USA, Canada and Germany. There were also different target populations, including healthcare, farm, production line and coke oven workers. Thereby readers should exercise caution when applying these findings to low- and middle-income countries, as well as other occupational sectors.

Quality of the evidence

We graded the quality of the evidence according to the GRADE system (GRADEpro 2008). We judged the evidence in one comparison as provided by one RCT to be low quality. We judged the quality of evidence provided by all the remaining 13 studies in all four comparisons to be very low. We downgraded the quality of evidence from high quality with one level because of study limitations and with another level due to imprecision of the estimate of intervention effect. We did not consider inconsistency or publication bias because there was only a single study included in all but one comparison. Six of the 14 included studies (43 %) used a controlled before and after study design. We found no reason

to upgrade the quality of evidence provided by these controlled before-after studies. All studies failed to control for selection bias or demonstrate that they had done so by, for example, rigorous allocation concealment. Seven studies included fewer than 100 participants, which is in our opinion insufficient given the small effects found in the studies.

Potential biases in the review process

Our primary outcome measure was use of RPE. However, this was measured in various ways as there is no standard instrument to measure RPE use. In some studies there was already a quite high level of RPE use to begin with and it was therefore more difficult to increase. However, we could not take this into account in our analyses. It is also difficult to predict in which direction this would have biased our results. It could have either decreased or increased the effects of the interventions.

We obtained all relevant studies that we identified from the search. We independently screened these potential studies, assessed risk of bias and extracted data from included studies, and we resolved disagreements by discussion. We were also able to successfully contact the authors of two included studies to clarify the reported RPE use (Dressel 2007; Perry 2003). Therefore, potential bias due to the review process should be minimal.

Agreements and disagreements with other studies or reviews

The findings of this review are similar to those of a systematic review that aimed to evaluate the effectiveness and processes of occupational-based behavioural interventions for workers exposed to dermal and respiratory hazards (Lunt 2011). They found that worker-focused behavioural interventions had a limited, albeit positive, impact upon exposure. This review assessed not only RPE use but also a broader range of behavioural indicators. However, this review did not include eight further studies that are included in our review (Carrico 2007; Donham 2011; Eckerman 2002; Gjerde 1991; Hannum 1996; Kim 2012; Myers 1995; Or 2012).

AUTHORS' CONCLUSIONS

Implications for practice

According to the evidence provided by this Cochrane review, behavioural interventions - namely education and training - do not have a considerable effect on the frequency or correctness of RPE use in workers. This may be due to a lack of studies with a low risk of bias. Interventions to promote the correct use of RPE need to be better evaluated to provide evidence for their effectiveness before any strong recommendations can be made. There were no studies on incentives.

Implications for research

There is a lack of studies with a low risk of bias that evaluate the effectiveness of behavioural interventions to promote RPE use. The interventions used in the studies included in this Cochrane review focus primarily on education and training. We need studies evaluating the effectiveness of other interventions and combinations of interventions to improve RPE use in workers compared with education only. Examples of these other interventions include: legislation and enforcement; incentives (e.g. monetary or positive feedback); sanctions and negative feedback; and changes in the organisational safety climate or culture.

Given the small effects reported in studies included in this Cochrane review, the sample size of new studies should be at least 400 participants. This sample size is based on an estimate of a small effect size of 0.2 (Norman 2012). New studies should use and clearly report randomised sequence generation, allocation concealment and assessor blinding. New studies should evaluate the effectiveness of behavioural interventions for improving the use of RPE at both an organisational and individual level using different types of workers. Studies should be conducted in both high-income as well as low- and middle-income country settings. Behavioural interventions targeted at the worker level should be carried out in small-scale industries in low- and middle-income countries, while those targeted at the national or organisational level should be conducted in larger organisations in high-income countries. Future studies should also consider and take into account the impact of known barriers to RPE use, such as perception of health risk, employers' attitude, and ease and comfort of use.

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CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Carrico 2007

Methods	**Cluster-randomised controlled trial** 20 participants were randomly assigned to either an intervention (n = 10) or control group (n = 10). The outcome was measured in 42 patients each for the intervention and control group. Clustering of nurses was not taken into account
Participants	**Setting:** a university hospital in the USA Registered nurses who were employed by the hospital; mobile or per diem nurses were excluded **Recruitment:** 20 participants were randomly assigned to an intervention or control group
Interventions	**Intervention:** classroom training plus bio-simulated visual training. The bio-simulator consisted of a patient dummy that could visualise with fluorescent powder how coughing disperses particles in the air. **Control:** only classroom training
Outcomes	1. Appropriate RPE use during patient care, as observed by 2 trained blinded observers. Observers noted if, in patients exhibiting respiratory symptoms, PPE items were used. This could be either that the nurse placed a mask on the patient or used a mask themselves. Both were considered valid protection techniques. Assessments were made in the weeks immediately following training. This outcome was measured in 42 patients in the intervention and control group. 2. Pre-and post teaching knowledge of respiratory pathogen transmission
Notes	Patient bio-simulator (Medical Education Technologies, Inc. (METI), Sarasota, FL)

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	The details of random sequence generation were not reported
Allocation concealment (selection bias)	Unclear risk	This information was not provided
Blinding of outcome assessment (detection bias) All outcomes	Low risk	The trained observers were blinded to the participants' group assignment
Incomplete outcome data (attrition bias) All outcomes	Low risk	All participants were observed and the main outcomes of appropriate RPE use during patient care was recorded
Selective reporting (reporting bias)	Low risk	Results of the 2 important outcomes mentioned, frequency of self-RPE use and use of RPE on patients, were presented

Carrico 2007 *(Continued)*

Similarity of baseline characteristics	Low risk	Balanced baseline characteristics between the 2 groups were reported

Donham 2011

Methods	**Randomise controlled trial** in 308 farms randomly recruited from farms in a 9-county area in Northwest Iowa between 1998 and 2003. The farms were stratified based on similarities of farm size, type of commodity production and frequency of self-reported farm injuries. They were paired within the strata, then randomly assigned to either Certified Safe Farm (CSF) or control group. Per farm the principal operator of the farm was the study unit.
Participants	**Setting:** 9-county area in Northwest Iowa, USA **Recruitment:** 308 farms (150 CSF intervention farms and 158 control farms) Principal operators of the farms, such as the primary owner or manager, were the study units Baseline characteristics of the farms and the principal operators of 2 groups were similar The exception was operator's education of which 39% of the CSF intervention group had bachelors degrees or higher compared to 27% in the control group
Interventions	**Intervention:** educational intervention. The CSF intervention was a multifaceted intervention consisting of 4 elements: 1. clinical occupational and wellness screening with fit testing of RPEs, 2. educational support: newsletters, website and meetings, 3. on-farm safety audits with set safety standard and 4. a performance incentive with a UDS200 payment for achieving at least 85% of the audit score. **Control:** no intervention
Outcomes	1. Use of respirator assessed by questionnaire: "What percentage of the time did you use respiratory protection when working among grain dust?". Answers of more than 75% were scored as 'use of RPE' and less than 75% as 'no use of RPE'. The outcome was assessed at baseline and yearly until 4 years after the intervention. 2. Occupational respiratory symptoms including airways symptoms and symptoms of organic dust toxic syndrome. Symptoms were self-reported using an assessment tool designed for farm organic dust exposure, as developed by Rylander and co-workers. At baseline there were 141 intervention farms that responded and 140 control farms, at year 1 the figures were 129 and 126, at year 2 this was 120 and 108, at year 3 this was 99 and 71 and at year 4 this was 75 and 55, respectively
Notes	—

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Reported that "These farms were then paired within strata of the variables mentioned above and randomly assigned to either the intervention or control group (CSF intervention, n =150 and controls, n =158)". No information on random sequence generation was presented.
Allocation concealment (selection bias)	Unclear risk	No information on allocation concealment was provided
Blinding of outcome assessment (detection bias)	Low risk	The trained interviewers who assessed occupational respiratory symptoms were blinded to the interventions

Donham 2011 *(Continued)*
All outcomes

Incomplete outcome data (attrition bias) All outcomes	High risk	308 farms (150 CSF intervention farm and 158 controls) were recruited, but 281 farms (91.2%), 141 CSF intervention farms and 140 controls, were analysed for respirator use and respiratory symptoms at entry Farms dropped out from the study every year (Table 3 in the paper). At the 4th year of follow-up results were reported from only 75 farms (50.0%) in the CSF intervention group and 55 farms (34.8%) in the control group.
Selective reporting (reporting bias)	Low risk	Results of the 2 important outcomes mentioned, respirator use and respiratory symptoms, were presented
Similarity of baseline characteristics	Low risk	The results show that the demographics and exposure characteristics of the CSF intervention and control groups were comparable

Dressel 2007

Methods	**Controlled before and after study**
Participants	**Setting:** Bavaria, Germany **Recruitment:** 105 out of 120 eligible farmers with occupational asthma mainly sensitised against cow dander and storage mites took part in a 1-day educational programme organised by 2 German statutory accident insurance institutions for the agricultural sector A total of 81 participants (49 males (mean ± SD age 49.8 ± 9.1 years) and 32 females (45.9 ± 8.6 years)) were included in the intervention group as they were regularly working at a stable and were able to return to the same location for a second visit 4 to 6 weeks after the intervention The control group comprised farmers with occupational asthma not participating in the educational programme (19 males (44.5 ± 10.9 years) and 5 females (41.2 ± 7.7 years)). They were visited at their farms for baseline measurement and again 4 to 6 weeks later.
Interventions	**Intervention:** 1-day educational programme. "The education, of 4–5 h duration, included two presentations by one of the authors of the present article (J. Sültz), who is a pulmonologist and occupational physician. The first presentation provided general information about the pathogenesis of asthma and allergies, environmental influences, medication and prevention. The second presentation gave details about major occupational allergens causing asthma, particularly cow dander and mites, with special focus on prevention in the workplace based on original data. All major issues were illustrated by examples drawn from the patients' cases. A representative of the insurance institution added further information about technical and organisational means of allergen avoidance and demonstrated the use of personal protective equipment." (page 546) **Control:** no intervention
Outcomes	Wearing headgear during stable work measured at baseline and at 4 to 6 weeks follow-up
Notes	Authors confirmed that the headgear in question meant some form of respirator mask; information requested by email to D Nowak on 23 October 2014

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	There was no allocation of participants into study groups: the intervention group consists of an opportunity sample of farmers participating in an edu-

Dressel 2007 *(Continued)*

		cational programme, whereas control group participants were sampled from those that did not participate
Allocation concealment (selection bias)	High risk	There was no allocation into groups
Blinding of outcome assessment (detection bias) All outcomes	High risk	Outcome assessment of behaviours was done by the participants themselves and thereby introduced a possible bias
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	The authors do not give any indication as to whether they followed up all study participants or if some were lost to follow-up
Selective reporting (reporting bias)	Low risk	All measured outcomes appear to have been reported
Similarity of baseline characteristics	High risk	Intervention group participants were significantly more often (73% versus 42%) currently experiencing one or more of the following respiratory symptoms at work: shortness of breath, cough with or without phlegm, wheeze or nasal irritation. Use of headgear was similar in both groups (76.5% versus 79.2%).

Eckerman 2002

Methods	**Randomised controlled trial**
Participants	**Setting:** Oregon Health Science University, USA **Recruitment:** 123 adults were recruited through advertisements in local newspapers, the website of Oregon Health and Science University, and flyers distributed at a liberal arts university
Interventions	**4 intervention groups:** 1. Programmed instruction (PI) active (n = 32) 2. PI passive (n = 31), 3. INFO-book (read book, non-interactive) (n = 20) 4. INFO-screen (read screen, non-interactive) (n = 32) The intervention provided basic respiratory protection information, addressing the following: uses (preventing symptoms), limitations (immediately dangerous to life or health conditions, seal, fit tests), and maintenance of air-purifying and supplied air respirators (SAR; valve, cartridge replacement); recognition of respiratory hazards (lead, solvents, carbon monoxide; acute and chronic effects); selection of proper respirators for different hazards (material safety data sheets (MSDS), product labels, permissible exposure limits) and measurement of hazard levels
Outcomes	Performance scores for basic respiratory protection information measured by quiz test contained four-item multiple-choice questionson done on the computer screen This outcome was assessed before and immediately, 1 week and 2 months after the intervention
Notes	—
Risk of bias	

Eckerman 2002 *(Continued)*

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "Participants were randomly assigned to conditions when they arrived." (page 315) However, there was no information on how randomisation was conducted
Allocation concealment (selection bias)	Unclear risk	No information provided
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not mentioned
Incomplete outcome data (attrition bias) All outcomes	High risk	At 2 months: 36 % (44/123) loss to follow-up, in which: 13/32 dropped out from PI active, 11/32 dropped out from PI passive, 8/28 dropped out from INFO-book and 12/32 dropped out from INFO-screen
Selective reporting (reporting bias)	Low risk	Expected outcomes were reported
Similarity of baseline characteristics	Unclear risk	No information provided

Gjerde 1991

Methods	**Controlled before and after study**
Participants	**Setting:** 108 (89%) of 121 farms producing pork that qualified from 7 counties in eastern Iowa, USA. Every farm contributed on average 2 workers; 88% were men; there were no differences in age, education or years in farming between the intervention and control group. **Recruitment:** 102 swine confinement workers from 7 southeastern counties in Iowa were designated as the intervention group and 107 swine confinement workers from 7 northeastern counties in Iowa as the control group
Interventions	**Intervention:** educational intervention consisting of a series of 6 educational home study modules, a project logo and an evening session in which respirator use and gas measurement were demonstrated. Of the intervention group 49 workers (48%) attended the evening session. **Control:** no intervention
Outcomes	Self-reported improvements of knowledge, attitudes and behaviours, of which one was dust mask use, at baseline and 1 year after intervention
Notes	—

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Study was not randomised
Allocation concealment (selection bias)	High risk	There was no allocation concealment

Gjerde 1991 *(Continued)*

Blinding of outcome assessment (detection bias) All outcomes	High risk	Assessment was done using a 13-item self-reported behaviours questionnaire in the study participants and thereby introduced a possible bias
Incomplete outcome data (attrition bias) All outcomes	High risk	In the intervention group (n = 102), 77 (75%) and 68 (67%) of participants provided useful information at baseline (T1) and 1 year after intervention (T2), respectively In the control group (n = 107), 95 (88%) and 86 (80%) participants provided useful information at T1 and T2, respectively Data appropriate for the chosen analyses were obtained from 49 participants in the intervention group and 79 participants in the non-intervention group
Selective reporting (reporting bias)	Low risk	All items in the assessment questionnaire were analysed
Similarity of baseline characteristics	Low risk	An analysis of the demographics of the 2 groups showed no significant differences with respect to age, education, years in farming or type of farming

Hannum 1996

Methods	**Controlled before and after study**
Participants	**Setting:** Veterans Affairs hospital, Virginia, USA **Recruitment:** 179 hospital employers in a 775-bed Veterans Affairs hospital
Interventions	**Intervention:** employees in Group A received one-on-one training by the hospital's industrial hygienist and were fit tested as part of this training using irritant smoke to test if the RPE fitted (N = 52) Employees in Group B received classroom instruction and demonstration by infection control nurses in the proper use of respirators, but were not fit tested as part of training (N = 64) Control: employees in Group C received no formal training (N = 63)
Outcomes	1. Correct fit of RPE: if there was coughing or detection of smoke during a qualitative fit test using irritant smoke the RPE was considered not to be adjusted correctly 2. Direct cost of each method of training 3. Cost of employee-hours lost during training
Notes	—

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Not a randomised study. The project started with participants being taught by the industrial hygienist (Group A). Later a group was taught by nurses (Group B) as the progress of individual training was slow. Additionally there was a group of those who had not received training (Group C).
Allocation concealment (selection bias)	High risk	There was no allocation concealment

Hannum 1996 *(Continued)*

Blinding of outcome assessment (detection bias) All outcomes	Low risk	The assessors of qualitative fit testing were blinded to the group (i.e. A, B or C) of the participant tested
Incomplete outcome data (attrition bias) All outcomes	Low risk	All 179 recruited healthcare workers provided data for the results that were analysed for qualitative fit test in respirator use
Selective reporting (reporting bias)	Low risk	Results of the 3 outcomes, qualitative fit test using, direct cost of each method of training and cost of employee-hours lost during training, were reported
Similarity of baseline characteristics	Unclear risk	No information available

Hung 2015

Methods	**Randomised controlled trial**
Participants	**Setting:** Hong Kong **Recruitment:** 50 healthcare workers (registered nurses, enrolled nurses, healthcare assistants) in the 24-hour outpatient department of a private hospital; able to read English, with basic computer operation skills
Interventions	**Intervention** (n = 25)**:** received conventional personal PPE training plus computer-simulated training using the proposed simulation program - web-based interactive software with a user-friendly graphical interface for users to practise the use of PPE via dragging and dropping various PPE onto a virtual healthcare worker and by responding to multiple choice questions online **Control group** (n = 25): received conventional PPE training
Outcomes	1. Performance in PPE donning and doffing, measured as scores for PPE use that included a N95 respirator, face-shield, cap, gown and gloves. The scores reflected overall skill in the use of PPE. 2. Errors in simulated training and user satisfaction with the use of the computer program (measured in the intervention group only) These outcomes were assessed 1 week after the training in the control group and after 2 weeks in the intervention group
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote from the first paragraph of Research Design and Procedure (page 53): "The subjects were randomly assigned to the control and experimental group of the same size."
Allocation concealment (selection bias)	Unclear risk	Quote from the first paragraph of Research Design and Procedure (page 53): "the subjects were randomly assigned to the control and experimental group of the same size.'
Blinding of outcome assessment (detection bias)	Unclear risk	Not stated whether the reviewers were blinded

Hung 2015 *(Continued)*

All outcomes		
Incomplete outcome data (attrition bias) All outcomes	Low risk	No mention of attrition
Selective reporting (reporting bias)	Low risk	Expected outcomes were reported
Similarity of baseline characteristics	Low risk	Comparable baseline characteristics are reported in Table 1 of the report

Kim 2012

Methods	**Controlled before and after study**
Participants	**Setting:** West Elgin Community Health Centre (WECHC), Canada **Recruitment:** 68 farmers were recruited via advertisements (local newspaper) and from previous surveys: 38 farmers attended the educational intervention and 30 farmers formed the control group
Interventions	**Intervention:** 1 evening educational programme at the WECHC, led by clinicians, safety consultants and suppliers of safety equipment. The programme consisted of rotating stations with information on work-related asthma and agricultural causes; spirometry testing; respirator demonstrations and fit testing; exposure reduction strategies; and barriers to personal protective equipment use. **Control group:** no intervention
Outcomes	1. Occupational health and safety (OHS) knowledge 2. Use of PPE including reported mask use, use of N95 mask, fit testing for N95, use of respirator (powered air purifying respirator) and use of mask while brushing animals 3. Dust and mould reduction strategies including no dry sweeping of spills, wet sweeping of spills, high efficiency particulate air filter use, spraying feed or bedding, ensuring crops are dry before storing and anti-mould spray use 4. Engineering and procedural controls including ventilation in grain storage areas, ventilation in bar, non-manual feeding system, exhaust generators outdoors and separate work and home laundry These outcomes were assessed using a self-completed questionnaire before and 6 months after intervention
Notes	—

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Not a randomised study
Allocation concealment (selection bias)	High risk	No allocation concealment Quote: "Participants who were able to attend the educational evening formed the intervention group; those unable to attend formed the control group. This pilot study was not randomized."
Blinding of outcome assessment (detection bias)	High risk	The self-completed questionnaire introduced a possible bias

Kim 2012 *(Continued)*

All outcomes		
Incomplete outcome data (attrition bias) All outcomes	High risk	76% (29/38) of the intervention group and 77% of the control group completed the follow-up survey 6 months after intervention
Selective reporting (reporting bias)	Low risk	Results of all expected outcomes were reported
Similarity of baseline characteristics	High risk	Most baseline characteristics were comparable between the 2 groups, but differences in terms of sex, type of farm and respiratory symptoms were reported (Table 1, page 459 of the paper) Results of the 3ree outcomes, qualitative fit test using, direct cost of each method of training and cost of employee-hours lost during training, were reported

Myers 1995

Methods	**Randomised controlled trial** No information on study period
Participants	**Setting:** USA **Recruitment:** 64 white-collar workers with inexperience of RPE use **Exclusion criteria:** direct affiliation or business responsibility with the research, design or manufacture of RPE; previous training in the use of RPE; previous experience with wearing RPE in their jobs; facial hair that would compromise the seal of RPE
Interventions	**Intervention** (n = 32)**:** training to don the RPE using the +/- fit check as an aid **Control** (n = 32)**:** training to don the RPE without conducting a +/- fit check The training period was 2 days
Outcomes	Successful RPE donning tested over 3 days immediately after training but the information was unclear how the authors measures successful RPE donning.
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	No information available. Quote: "Subjects were randomly divided into three groups."
Allocation concealment (selection bias)	Unclear risk	No information available. Quote: "Subjects were randomly divided into three groups."
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No information provided
Incomplete outcome data (attrition bias)	Unclear risk	Unclear information

Myers 1995 *(Continued)*

All outcomes		
Selective reporting (reporting bias)	Unclear risk	Unclear outcome reported
Similarity of baseline characteristics	Unclear risk	No information provided

Navidian 2015

Methods	**Controlled before and after study** January to August 2014
Participants	**Setting:** Hamedan, Iran **Recruitment:** 70 production line workers at glass production facilities **Exclusion criteria:** participation in safety education classes during the last year, having a history of occupational injury or trauma, the presence of disease or other physical limitation, illiteracy and absence from more than one educational session
Interventions	**Intervention** (n = 35)**:** 4 educational sessions based on motivational interviewing, which were conducted in 4 groups of 8 to 10 participants **Control group** (n = 35): participants attended 4 x 1-hour safety education sessions that were conducted as traditional lectures
Outcomes	Safety awareness, attitude and performance in the use of PPE which included respirators but the specific data of RPE use was not reported. These outcomes were assessed before and 12 weeks after the intervention
Notes	—

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote from the first paragraph of Methods on page 3: "Based on the sample volume formula with α = 5 % and test power of 90 %, 35 subjects were randomly assigned to the intervention group and 35 to the control group."
Allocation concealment (selection bias)	Unclear risk	Quote from the first paragraph of Methods on page 3: "Based on the sample volume formula with α = 5 % and test power of 90 %, 35 subjects were randomly assigned to the intervention group and 35 to the control group."
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not mentioned in the paper
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Not mentioned in the paper
Selective reporting (reporting bias)	Low risk	All expected outcomes were reported

Navidian 2015 *(Continued)*

Similarity of baseline characteristics	Low risk	The baseline characteristics were comparable

Or 2012

Methods	**Randomised controlled trial**
Participants	**Setting:** department of nursing and health sciences, Hong Kong, China **Recruitment:** 84 first-year undergraduate nursing students with previous inexperience in respirator fit testing or fit checking. They were randomly divided into 4 intervention groups. Each group included 21 students.
Interventions	**Group A:** conventional quantitative PortaCount fit test with fit check training **Group B:** no conventional PortaCount fit test with fit check training **Group C:** conventional PortaCount fit test without fit check training **Group D:** no conventional PortaCount fit test without fit check training
Outcomes	Respirator fitness. The measurements were conducted continuously for 15 minutes, with particle concentration measurements averaged over 1 minute.
Notes	—

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "The participants were divided randomly into four groups..." (page 512) No information on how randomisation was actually done
Allocation concealment (selection bias)	Unclear risk	No information provided
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No information available about who assessed the respirator fitness
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	No information provided
Selective reporting (reporting bias)	High risk	Expected outcomes were not presented clearly
Similarity of baseline characteristics	Low risk	Baseline characteristics were similar among groups. Quote: "One-way ANOVA compared the means of participants' ages, heights, and weights in the four groups; no statistically significant differences were found. Chi-square tests were used to analyze the other demographic variables; no significant differences were found. No significant differences of fit factors while performing nursing procedures were found among the four groups." (page 513)

Parkinson 1989

Methods	**Cluster-randomised controlled trial**
Participants	**Setting:** USA and Canada **Recruitment:** 14 coke plants, or 7 pairs (6 American; 1 Canadian), matched regarding geographic location, work force size and ethnic composition, were chosen from the population of 28 operating coke oven facilities in the USA and Canada in 1984. In each pair one would be randomly assigned to receive the education programme and the other would serve as the control plant. From the intervention cluster 209 workers were randomly chosen for the intervention and likewise 119 workers from the control cluster.
Interventions	**Intervention:** education programme. "The educational program was composed of four core modules. The first module provided an overview of the history of the USWA's activities in improving the safety and health conditions of coke oven plants. The second module provided information about the types of cancer associated with coke plant work and the components of as effective medical surveillance program. The third module delineated the provisions of the OSHA Coke Oven Standard. In this module, information on personal workplace practices (eg, using respirators, engaging in hygienic behavior, refraining from eating or drinking in regulated areas, etc) as well as proper engineering controls was discussed. Finally, the fourth module described the current status of the control program at each plant." "The educational program was delivered on four occasions during a 2-year period at each of seven coke oven plants. Although the core program, which was formally evaluated, remained constant, the programs were also augmented to meet specific requests and/or needs of individual plants. Thus, additional information was presented on such topics as techniques for diagnosing lung cancer, workers' compensation, types of respirators, and results of government actions (OSHA and/or Environmental Protection Agency inspections) which had taken place at the plant." (page 465) **Control:** no intervention
Outcomes	1. Knowledge of the coke oven standard 2. Knowledge of cancer hazards 3. Personal workplace practice (wash face/wash hands before lunch, shower at plant, eat or drink anything other than water on battery, smokers who smoke last year, had physical in last year, wear face shield/safety glasses/goggles, wear respiratory) They were assessed beforeand 1 month and 6ix months after each intervention programme
Notes	Results for interventions are presented only as repeated measures ANOVA results

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "From the population of 28 operating coke oven facilities in the United States and Canada in 1984, we sought to select pairs of plants in which one (the “experimental” plant) would be randomly assigned to receive the education program and the other would serve as the control plant." (page 466) The authors do not give any details on how they performed the randomisation
Allocation concealment (selection bias)	Unclear risk	The authors do not give any details about allocation concealment
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Given the nature of the intervention, it was not possible to blind the participants or the intervention providers. However, the telephone interviewers ob-

Parkinson 1989 *(Continued)*

		taining follow-up data could have been blinded but the authors do not report whether this was done.
Incomplete outcome data (attrition bias) All outcomes	High risk	The authors do not report what happened to participants lost to follow-up
Selective reporting (reporting bias)	High risk	The authors do not report all the same data at follow-up as at baseline
Similarity of baseline characteristics	Unclear risk	Quote: "The one issue on which the groups differed was their baseline level of job-related health concerns. As Table 2 shows, participants were more likely to acknowledge such concerns than were non-participants, that is, workers from the same plants who did not attend the program." (page 468)

Perry 2003

Methods	**Randomised controlled trial**
Participants	**Setting:** 400 dairy farmers certified to apply pesticides to field crops, Wisconsin, USA **Recruitment:** 100 participants were allocated to the interventiongroup and 300 were in the control group A total of 385 participants completed the follow-up interview
Interventions	**Intervention:** educational intervention (3 hours of education sessions) 3-hour educational sessions were conducted with approximately 100 randomly assigned participants. Sessions targeted 4 educational messages: (1) existing evidence of excess cancers among farmers; (2) simulation of pesticide exposure presented through a slide show and description; (3) feedback of self-reported data collected from the farmers, reporting on frequency of exposure and gear use; and (4) cognitive behavioural strategies that can be adopted to reduce pesticide hazards. **Control:** attended the standard re-certification meeting
Outcomes	1. Use of protective gear (use of any gear other than gloves during the most recent application) 2. Full PPE compliance, including the self-reported use of PPE including a respirator. However, the specific information on use of the respirator could not be extracted from the PPE compliance outcome. 3. Self-reported dermal exposure during the most recent application 4. Decreased number of pesticides applied These outcomes were assessed 6 months after intervention
Notes	—

Risk of bias

Bias	Authors' judgement	Support for judgement

Perry 2003 *(Continued)*

Random sequence generation (selection bias)	Low risk	A computer-generated randomisation method was used to allocate participants to each intervention group
Allocation concealment (selection bias)	Unclear risk	This information was not reported
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Blinded participants and outcome assessors
Incomplete outcome data (attrition bias) All outcomes	Low risk	Each participant was interviewed over the telephone on 2 occasions after their first pesticide application of the season and attended a winter pesticide re-certification meeting. The loss to follow-up was 6 out of 100 farmers in the intervention group and 9 out of 300 farmers in the control group.
Selective reporting (reporting bias)	Low risk	All items in the questionnaire were reported
Similarity of baseline characteristics	Low risk	Baseline demographic and pesticide application practices in the 2 treatment groups were not different between the groups

Shamsi 2015

Methods	**Controlled before and after study**
Participants	**Setting:** Isfahan, Iran **Participants:** 44 workers constructing 2 subway stations in Isfahan. Workers in random subway stations under construction from the north region formed the intervention group and workers in random subway stations under construction from the central region of Isfahan were the control group. They were far away from each other and had no relationship.
Interventions	**Intervention** (n = 23)**:** received a free package containing a safety helmet with a tailored message affixed to it, a dust mask and safety gloves and an educational pamphlet. This was a 4-week intervention. **Control group** (n = 21): received no training
Outcomes	Use of PPE including the use of helmet, safety mask, safety gloves and safety shoes while working. Using a safety mask while working was considered to be RPE use. These outcomes were measured before and after 6 weeks
Notes	—

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Not done
Allocation concealment (selection bias)	High risk	Not done
Blinding of outcome assessment (detection bias)	High risk	Self-reported behaviours

Shamsi 2015 *(Continued)*

All outcomes		
Incomplete outcome data (attrition bias) All outcomes	Low risk	Not reported
Selective reporting (reporting bias)	Low risk	All expected outcomes were presented
Similarity of baseline characteristics	Low risk	The 2 groups had no significant differences in demographic variables such as age, daily work hours, literacy level and work history

CSF: Certified Safe Farm
PI: programmed instruction
PPE: personal protective equipment
RPE: respiratory protective equipment
SD: standard deviation

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Adewoye 2014	This study aimed to assess the effect of a health education intervention on awareness and practices of occupational safety among electric arc welders. It is not related to our review objective.
Bailey 2010	The intervention in this study emphasised both skin and respiratory protection measures. The outcome that was measured was the incidence of sensitisation, which was not one of our inclusion criteria.
Becker 2004	The study was only a survey comparing worker activities before and after a training programme.
Casalino 2015	This study aimed to compare two different strategies for training students in the proficient use of personal protective equipment (PPE) and to evaluate the frequency and number of errors occurring during donning and doffing of the PPE currently proposed for protecting healthcare workers against ebola virus disease. It is not related to our review objective of evaluating behavioural interventions for promoting respiratory protection use.
Contreras 2012	This was a correlative study to evaluate PPE use after training and PPE distribution. Respirator use was part of the training. However, no comparative results were assessed in a control group.
Crippa 2007	This study aimed to assess the efficacy of a specific educational programme in one group of hairdressing trainees, aged from 15 to 21 years, attending three technical schools, without a control group.
Fu 2013	This was a before and after participatory training study in one group of welders from small and medium sized enterprises in China.
Gershon 2009	This was an experimental pre-post intervention study in one group of emergency medical services workers in the USA.
Harber 2013	This study did not aim to increase the use of RPE.
Harber 2014	This study did not aim to increase the use of RPE.

Study	Reason for exclusion
Huaroto 2013	This study had only one pre- and two post-intervention measurements from one group. Participants were healthcare workers exposed to biologic hazards, including tuberculosis. The type of intervention was information-training.
Jenkins 2007	This was a non-randomised, non-controlled study. It had only one pre-post intervention group for assessing the improvement in PPE use in dairy farmers.
Myong 2016	This was a before and after study with only two time points in one group of medical students.
Woith 2015	This was a one-group experiment to assess the feasibility of a photovoice study on promoting respirator use in healthcare workers.

PPE: personal protective equipment
RPE: respiratory protective equipment

Characteristics of ongoing studies *[ordered by study ID]*

Chen 2016

Trial name or title	Study protocol: a cluster randomized controlled trial to assess the effectiveness of a multi-pronged behavioural intervention to improve use of personal protective equipment among migrant workers exposed to organic solvents in small and medium-sized enterprises
Methods	This cluster RCT will be conducted in Baiyun district in Guangzhou, China.
Participants	920 Migrant workers who do not have local registered permanent residence, are the first-line production workers exposed to organic solvents, working for more than 1 month in the 60 investigated enterprises.
Interventions	**Intervention arm 1** (n = 20 enterprises): A top-down intervention including: 1. Occupational health education towards managers and occupational health personnel in each enterprise will be accomplished in the first week of intervention by trained educators. It will focus on enterprises' responsibilities on occupational health; and benefits they will gain by creating a healthy workplace and improving workers' health; as well as activities they could take to achieve the goal, e.g. providing appropriate PPE and establishing and enforcing a supervision plan. 2. General health education: One lecture on PPE utilization will be organised among migrant workers in the first week of intervention, delivered by two trained educators. The lecture will focus on the introduction of organic solvents, dangers of not using PPE, and how to properly select, use and store of PPE. Related brochures and posters will be delivered to migrant workers at baseline and 3-month follow-up of intervention. 3. mHealth intervention: PPE utilization and other related occupational health messages will be sent twice a week through Instant Message Apps, including WeChat, Tencent QQ and Fetion, depending on which App is more commonly used by each migrant worker. **Intervention arm 2** (n = 20 enterprises): A comprehensive intervention, including: 1. The same intervention as that in the intervention arm 1; 2. Peer education will be organised once a month. Each peer group will include 8–15 migrant workers and one of them will be assigned as a group leader based on the voluntary principle. Group leaders will receive a course on peer education and a handbook designed by the research team (WC, XL and SF), as well as establish contact with our project coordinators (TL, FZ, SH and JS) to send feedback and get help timely. The overall 6 monthly peer educations will be launched by group leaders for no longer than 60 min each time. The intervention will begin with an ice-breaking game and introduction of peer education in the 1st month, followed by organic solvents and the

Chen 2016 *(Continued)*

	related protection education in the 2nd month, how to use PPE and personal experiences of benefits and barriers of use PPE in the 3rd-5th months, and maintenance of PPE utilization in the 6th month. In addition, group leaders will be asked to monitor other group members' PPE utilization behaviour in the workplace. Every month, all group leaders will receive 50 RMB (8 $USD) and the top five best performing leaders will receive additional 50 RMB as a token of appreciation. **Control arm** (n = 20 enterprises): No intervention.
Outcomes	1. Self reported PPE use during the last week (i.e. organic respirator, dust mask or surgical mask) 2. Occupational health knowledge will be measured by 10 questions related to organic solvents and PPE utilization. Questions were designed by the researchers according to "The usage criterion of personal protective equipment against occupational diseases in organic solvents workplace". Correct answer for each question will achieve a score of 1, giving a total possible score of 10. 3. Attitude towards PPE utilization. A scale of 9 items was developed by the researchers to assess migrant workers' attitude towards PPE utilization. The scale includes four dimensions, i.e. willingness to use, self-efficacy and perceived benefits and barriers. This measure will comprise 9 items and each will be rated on a 5-point Likert scale with 'strongly agree' scoring 5 and 'strongly disagree' scoring 1, giving an overall score ranging between 9 and 45. 4. Participation in occupational health check-up will be measured by whether migrant workers have taken part in occupational health check-up during the past 6 months, and the number of occupational health check-ups migrant workers have received. Data will be collected at baseline, 3-month follow-up and 6-month follow-up (the end of the intervention), respectively.
Starting date	This trial will last 6 months.
Contact information	lingli@mail.sysu.edu.cn
Notes	

DATA AND ANALYSES

Comparison 1. Training versus no intervention

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Properly fitting RPE	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
1.1 Healthcare workers fit tested at 6 months follow-up	1		Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
1.2 Healthcare workers not fit tested at 6 months follow-up	1		Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]

Analysis 1.1. Comparison 1 Training versus no intervention, Outcome 1 Properly fitting RPE.

Study or subgroup	Training + fit test demo n/N	No intervention n/N	Risk Ratio M-H, Fixed, 95% CI	Risk Ratio M-H, Fixed, 95% CI
1.1.1 Healthcare workers fit tested at 6 months follow-up				
Hannum 1996	49/52	25/31		1.17[0.97,1.41]
1.1.2 Healthcare workers not fit tested at 6 months follow-up				
Hannum 1996	58/64	25/32		1.16[0.95,1.42]
		No intervention	0.5 0.7 1 1.5 2	Training + fit test demo

Comparison 2. Conventional training plus additions versus conventional training

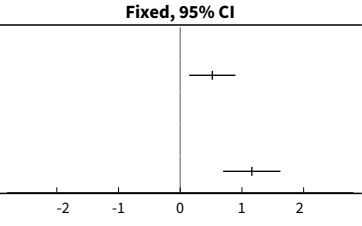
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Observed appropriate RPE use	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
2 Correct use of RPE as part of full-body PPE	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2.1 Donning	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
2.2 Doffing	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
3 Knowledge of RPE use at one-week follow-up	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3.1 PI-active versus PI-passive	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
3.2 PI-active versus INFO-book	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
3.3 PI-active versus INFO-screen	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
3.4 PI-passive versus INFO-book	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
3.5 PI-passive versus INFO-screen	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

Analysis 2.1. Comparison 2 Conventional training plus additions versus conventional training, Outcome 1 Observed appropriate RPE use.

Study or subgroup	Formal training + other n/N	Formal training n/N	Risk Ratio M-H, Fixed, 95% CI	Risk Ratio M-H, Fixed, 95% CI
Carrico 2007	24/32	17/32		1.41[0.96,2.07]
		Formal training	0.5 0.7 1 1.5 2	Formal training + other

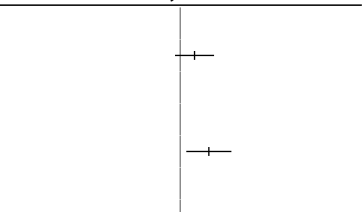
Analysis 2.2. Comparison 2 Conventional training plus additions versus conventional training, Outcome 2 Correct use of RPE as part of full-body PPE.

Study or subgroup	Conventional PPE training N	Conventional PPE training Mean(SD)	Computer simulation N	Computer simulation Mean(SD)	Mean Difference Fixed, 95% CI	Mean Difference Fixed, 95% CI
2.2.1 Donning						
Hung 2015	25	15.1 (0.5)	25	14.6 (0.8)		0.52[0.14,0.9]
2.2.2 Doffing						
Hung 2015	25	19.5 (0.7)	25	18.3 (1)		1.16[0.7,1.62]



Analysis 2.3. Comparison 2 Conventional training plus additions versus conventional training, Outcome 3 Knowledge of RPE use at one-week follow-up.

Study or subgroup	Intervention N	Intervention Mean(SD)	Control N	Control Mean(SD)	Mean Difference Fixed, 95% CI	Mean Difference Fixed, 95% CI
2.3.1 PI-active versus PI-passive						
Eckerman 2002	32	48.1 (5.8)	31	46 (5.8)		2.1[-0.76,4.96]
2.3.2 PI-active versus INFO-book						
Eckerman 2002	32	48.1 (5.8)	28	43.9 (7.1)		4.2[0.89,7.51]
2.3.3 PI-active versus INFO-screen						
Eckerman 2002	32	48.1 (5.8)	32	41.1 (6.2)		7[4.06,9.94]
2.3.4 PI-passive versus INFO-book						
Eckerman 2002	31	46 (5.8)	28	43.9 (7.1)		2.1[-1.23,5.43]
2.3.5 PI-passive versus INFO-screen						
Eckerman 2002	31	46 (5.8)	32	41.1 (6.2)		4.9[1.94,7.86]



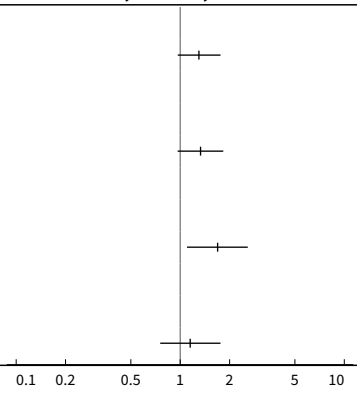
Comparison 3. Education versus no intervention

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Use of RPE most of the time	1		Risk Ratio (M-H, Random, 95% CI)	Totals not selected
1.1 1 year after intervention	1		Risk Ratio (M-H, Random, 95% CI)	0.0 [0.0, 0.0]
1.2 2 years after intervention	1		Risk Ratio (M-H, Random, 95% CI)	0.0 [0.0, 0.0]
1.3 3 years after intervention	1		Risk Ratio (M-H, Random, 95% CI)	0.0 [0.0, 0.0]
1.4 4 years after intervention	1		Risk Ratio (M-H, Random, 95% CI)	0.0 [0.0, 0.0]
2 Reported RPE use among farmers	3		Risk Ratio (M-H, Fixed, 95% CI)	Subtotals only

Outcome or subgroup title	No. of studies	No. of partici-pants	Statistical method	Effect size
2.1 Short term follw-up (6 weeks)	1	105	Risk Ratio (M-H, Fixed, 95% CI)	1.07 [0.91, 1.26]
2.2 Long term follow up (6 months - 1 year)	2	206	Risk Ratio (M-H, Fixed, 95% CI)	0.99 [0.84, 1.17]
3 Using safety mask while working	1		Risk Ratio (M-H, Fixed, 95% CI)	Subtotals only
4 Use of RPE (PAPR)	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
5 Fit tested for N95	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
6 Use of N95 mask	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected

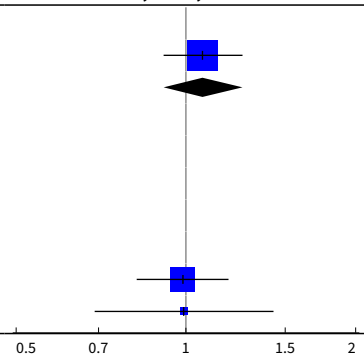
Analysis 3.1. Comparison 3 Education versus no intervention, Outcome 1 Use of RPE most of the time.

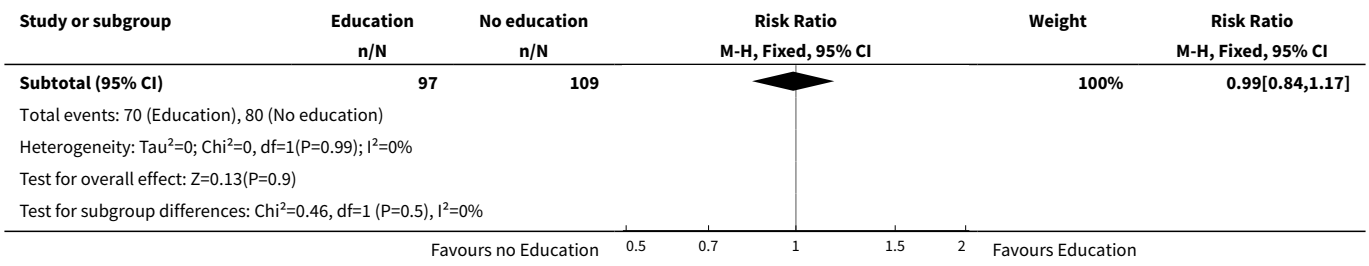
Study or subgroup	Multifaceted education n/N	No intervention n/N	Risk Ratio M-H, Random, 95% CI	Risk Ratio M-H, Random, 95% CI
3.1.1 1 year after intervention				
Donham 2011	60/129	45/126		1.3[0.97,1.76]
3.1.2 2 years after intervention				
Donham 2011	56/120	38/108		1.33[0.96,1.83]
3.1.3 3 years after intervention				
Donham 2011	47/99	20/71		1.69[1.1,2.58]
3.1.4 4 years after intervention				
Donham 2011	33/75	21/55		1.15[0.76,1.76]



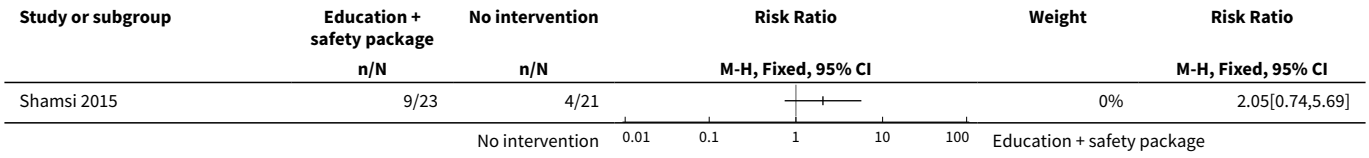
Analysis 3.2. Comparison 3 Education versus no intervention, Outcome 2 Reported RPE use among farmers.

Study or subgroup	Education n/N	No education n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
3.2.1 Short term follw-up (6 weeks)					
Dressel 2007	76/81	21/24		100%	1.07[0.91,1.26]
Subtotal (95% CI)	**81**	**24**		**100%**	**1.07[0.91,1.26]**
Total events: 76 (Education), 21 (No education)					
Heterogeneity: Not applicable					
Test for overall effect: Z=0.85(P=0.4)					
3.2.2 Long term follow up (6 months - 1 year)					
Gjerde 1991	50/68	64/86		76%	0.99[0.82,1.19]
Kim 2012	20/29	16/23		24%	0.99[0.69,1.43]

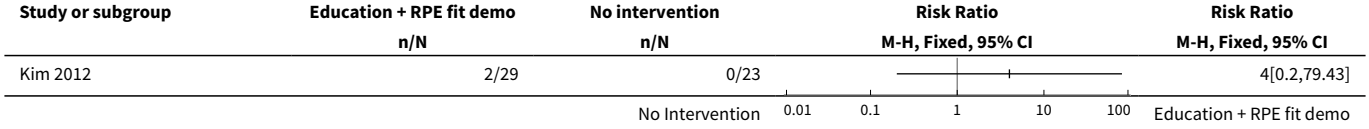




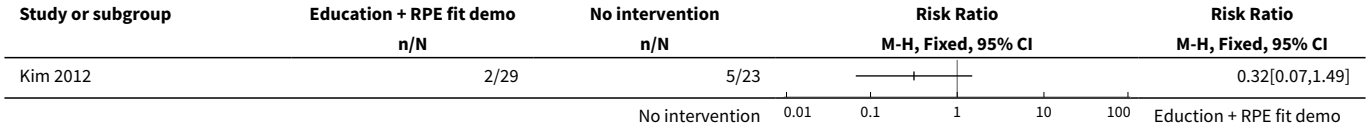
Analysis 3.3. Comparison 3 Education versus no intervention, Outcome 3 Using safety mask while working.



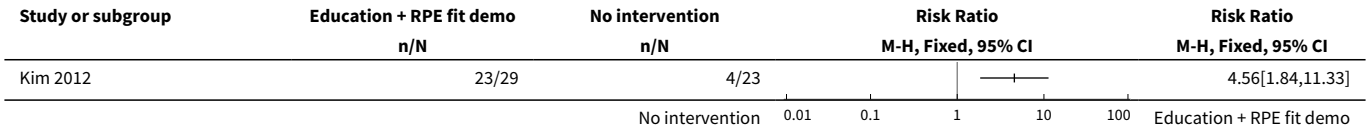
Analysis 3.4. Comparison 3 Education versus no intervention, Outcome 4 Use of RPE (PAPR).



Analysis 3.5. Comparison 3 Education versus no intervention, Outcome 5 Fit tested for N95.



Analysis 3.6. Comparison 3 Education versus no intervention, Outcome 6 Use of N95 mask.

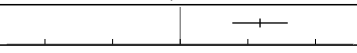


Comparison 4. Motivational interview-based education versus traditional lectures

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Use of RPE as part of full-body PPE	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Analysis 4.1. Comparison 4 Motivational interview-based education versus traditional lectures, Outcome 1 Use of RPE as part of full-body PPE.

Study or subgroup	Motivational interview		Traditional lectures		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Navidian 2015	35	11.2 (2.1)	35	8.2 (2.2)		2.95[1.93,3.97]



ADDITIONAL TABLES

Table 1. Details of interventions in included studies

Studies	Intervention details						Controls
	Education and training	Demonstration of respirator	Fit test	Audit	Session duration	Follow-up time	
Carrico 2007	Supplemental training in addition to classroom training, using a visual demonstration of respiration particle dispersion involving the use of a patient bio-simulator	Yes	No	Yes, observations in practice	No details	3 months	Standard classroom teaching
Donham 2011	Education: newsletter, website, yearly group educational session	Yes	Yes	Yes, annual on-farm safety audit with set standards; financial incentives	No details	4 years	No intervention
Dressel 2007	2 educational sessions	Yes	No	No	2 to 2.5 hours	4 to 6 weeks	No intervention
Eckerman 2002	Interactive training intervention, provided basic respiratory protection information	No	No	No	No details	2 weeks	Reading training
Hung 2015	Conventional PPE training plus computer-simulated training using the proposed simulation program	Yes	No	No	Not mentioned	1 week for the control group and 2 weeks for the intervention group	Conventional PPE training
Gjerde 1991	6 educational home study modules and 1 evening session in which respirator use and gas measurement were demonstrated	Yes	No	No	No details	1 year	No intervention without any detail
Hannum 1996	One-on-one training by the hospital hygienist, plus fit test Classroom instruction and demonstration by infection control nurses	Yes	Yes	No	No details	3 months	No formal training
Kim 2012	Education on work-related asthma and agricultural causes; spirometry testing; respirator	Yes	Yes	No	1 evening	6 months	No intervention

Table 1. Details of interventions in included studies *(Continued)*

	demonstrations and fit testing; exposure reduction strategies; barriers to PPE use						
Myers 1995	Training on donning the RPE using the +/- fit check	No	Yes	No	2 days	3 days	Training on donning the RPE without using the +/- fit check
Navidian 2015	4 educational sessions based on motivational group interviewing	No	No	No	Twice a week	12 weeks	1-hour safety education sessions that were conducted as traditional lectures
Or 2012	Conventional quantitative PortaCount fit test training	No	Intervention Group A and B: yes Intervention Group C: no	No	No details	No details	No training
Parkinson 1989	4 educational sessions	Unclear	Unclear	No	No details	6 months	No intervention
Perry 2003	Educational sessions targeting 4 educational messages in groups of 100 people	No	No	No	3 hours	6 months	Standard re-certification meeting
Shamsi 2015	Received a free package containing a safety helmet with a tailored message affixed to it, a dust mask and safety gloves, and an educational pamphlet	No	No	No	Not mentioned	4 weeks	No training

PPE: personal protective equipment

APPENDICES

Appendix 1. MEDLINE (PubMed) search strategy

#1	"respiratory protection" OR "respiratory protective" OR respirator OR respirators OR "personal protective equipment" OR "personal protective equipments" OR "Respiratory Protective Devices"[Mesh] OR ((personal protect*[tw] OR worker protect*[tw] OR workers protect*[tw] OR protective measure*[tw]) AND (dust[tw] OR dusts[tw] OR mist[tw] OR mists[tw] OR vapor*[tw] OR vapour*[tw] OR fog[tw] OR fogs[tw] OR fume[tw] OR fumes[tw] OR smoke[tw] OR smokes*[tw] OR solvents[tw] OR volatile[tw] OR chemical*[tw] OR biological*[tw] OR SARS[tw] OR hazardous substance*[tw] OR hazardous material*[tw] OR dangerous substance*[tw] OR asbestos*[tw] OR particle*[tw] OR nanoparticle*[tw]))
#2	work[tw] OR works*[tw] OR work'*[tw] OR worka*[tw] OR worke*[tw]OR workg*[tw] OR worki*[tw] OR workl*[tw] OR workp*[tw] OR occupation*[tw] OR job[tw] OR jobs [tw] OR employee*[tw] OR organisation*[tw] OR organization*[tw] OR laborer*[tw] OR labourer*[tw] OR construction industry[tw] OR firefight*[tw] OR miners[tw] OR fishing[tw] OR mining[tw] OR constructors[tw] OR "Agriculture"[Mesh] OR "Industry"[Mesh] OR "Occupational Groups"[Mesh] OR "Health Occupations"[Mesh]
#3	training[tw] OR program[tw] OR programs[tw] OR strategy[tw] OR strategies[tw] OR advise*[tw] OR adviso*[tw] OR guidelines[tw] OR behav*[tw] OR intervention*[tw] OR attitude*[tw] OR promot*[tw] OR safety culture[tw] OR safety awareness[tw] OR safety climate[tw] OR cognitive model*[tw] OR maintenance[tw] OR fit testing[tw] OR fit test*[tw] OR incentive*[tw] OR supervis*[tw] OR positive reinforcement[tw] OR social cognitive[tw] OR social model* [tw] OR health belief model*[tw] OR reasoned action[tw] OR frequent feedback[tw] OR organizational polic*[tw] OR organisational polic*[tw]
#4	penalty[tw] OR penalties[tw] OR enforcement[tw] OR sanction[tw] OR sanctions[tw] OR fines[tw] OR warning[tw] OR warnings[tw] OR feedback[tw] OR “legislation and jurisprudence” [sh] OR legislation[tw] OR legislative[tw] OR regulations[tw] OR regulative[tw]
#5	#1 AND #2 AND (#3 OR #4)

Appendix 2. Embase search strategy

#1	(respiratory NEXT/1 protect* OR respirator OR respirators OR ‘gas mask’):de,ab,ti
#2	(personal NEXT/2 protect* OR worker* NEAR/2 protect* OR protective NEXT/1 measure*):de,ab,ti
#3	'solvent'/exp OR 'dust'/exp OR 'severe acute respiratory syndrome':de OR ‘dangerous goods’:de OR 'volatile organic compound':de OR asbestos:de
#4	(sars OR dust* OR mist OR mists OR vapor* OR vapour* OR fog OR fogs OR fume OR fumes OR smoke OR smokes OR solvents OR volatile OR chemical* OR biological* OR 'hazardous substances' OR 'hazardous material' OR 'dangerous substances' OR asbestos* OR particle* OR nanoparticle* OR gas):de,ab,ti

(Continued)

#5	#3 OR #4
#6	#1 OR (#2 AND #5)
#7	'construction work'/exp OR 'mining'/exp OR 'fishing'/exp OR 'agriculture'/exp OR 'nonmedical occupations'/exp OR 'health care personnel'/exp OR 'worker'/de OR 'industry'/exp OR 'work'/exp
#8	(work* OR occupation* OR job OR jobs OR employee* OR organisation* OR organization* OR laborer* OR labourer* OR 'construction Industry' OR firefight* OR miners OR fishing OR mining OR constructors OR agriculture OR industry OR 'occupational groups' OR 'health occupations'):de,ab,ti
#9	#7 OR #8
#10	'feedback system'/exp OR 'practice guideline'/exp OR 'behavior change'/exp OR 'policy'/de OR 'punishment'/de OR 'law enforcement'/exp
#11	(training OR program OR programs OR strategy OR strategies OR advise* OR adviso* OR guidelines OR guidance OR behav* OR intervention* OR attitude* OR promot* OR 'safety culture' OR 'safety awareness' OR 'safety climate' OR cognitive NEXT/1 model* OR maintenance OR fit NEXT/1 test* OR incentive* OR supervis* OR 'positive reinforcement' OR 'social cognitive' OR social NEXT/1 model* OR 'health belief' NEXT/1 model* OR 'reasoned action' OR 'frequent feedback' OR organizational NEXT/1 polic* OR organisational NEXT/1 polic*):de,ab,ti
#12	(penalty OR penalties OR enforcement OR sanction OR sanctions OR fines OR warning OR warnings OR feedback OR legislation OR legislative OR regulations OR regulative OR 'labour inspection'):de,ab,ti
#13	#10 OR #11 OR #12
#14	#6 AND #9 AND #13
#15	#14 AND [embase]/lim NOT [medline]/lim

Appendix 3. CENTRAL search strategy

#1	MeSH descriptor: [Respiratory Protective Devices] explode all trees
#2	MeSH descriptor: [Masks] this term only
#3	"respiratory protection" or "respiratory protective" or respirator or respirators or "personal protective equipment" or "personal protective equipments":ti,ab,kw (Word variations have been searched)
#4	#1 OR #2 OR #3
#5	personal next protect* or worker next protect* or workers next protect* or protective next measure*:ti,ab,kw (Word variations have been searched
#6	MeSH descriptor: [Air Pollutants, Occupational] explode all trees

(Continued)

#7	MeSH descriptor: [Particulate Matter] explode all trees
#8	dust* or mist or mists or vapor* or vapour* or fog or fogs or fume or fumes or smoke or smokes or solvents or volatile or chemical* or biological* or SARS or hazardous next substance* or hazardous next material* or dangerous next substance* or asbestos* or particle* or nanoparticle*:ti,ab,kw (Word variations have been searched)
#9	#6OR #7 OR #8
#10	#5 AND #9
#11	work* or occupation* or job or jobs or employee* or organisation* or organization* or laborer* or labourer* or construction next industry or firefight* or miners or fishing or mining or constructors:ti,ab,kw (Word variations have been searched)
#12	MeSH descriptor: [Agriculture] explode all trees
#13	MeSH descriptor: [Industry] explode all trees
#14	MeSH descriptor: [Occupational Groups] explode all trees
#15	MeSH descriptor: [Health Occupations] explode all trees
#16	#12 OR #13 OR #14 OR #15
#17	#4 AND #16
#18	#10 OR #17
#19	training or program or programs or strategy or strategies or advise* or adviso* or guidelines or behav* or intervention* or attitude* or promot* or safety next culture or safety next awareness or safety next climate or cognitive next model* or maintenance or fit next test* or incentive* or supervis* or positive next reinforcement or social next cognitive or social next model* or health next belief next model* or reasoned next action or frequent next feedback or organizational next polic*:ti,ab,kw (Word variations have been searched)
#20	penalty or penalties or enforcement or sanction or sanctions or fines or warning or warnings or feedback or legislation or legislative or regulation* or regulative:ti,ab,kw (Word variations have been searched)
#21	#19 OR #20
#22	#18 AND #21 (24) > 22 Central Trials references

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#1	MeSH descriptor: [Respiratory Protective Devices] explode all trees
#2	MeSH descriptor: [Masks] this term only
#3	"respiratory protection" or "respiratory protective" or respirator or respirators or "personal protective equipment" or "personal protective equipments":ti,ab,kw

(Continued)

#4	#1 OR #2 OR #3
#5	personal next protect* or worker next protect* or workers next protect* or protective next measure*:ti,ab,kw
#6	MeSH descriptor: [Air Pollutants, Occupational] explode all trees
#7	MeSH descriptor: [Particulate Matter] explode all trees
#8	dust* or mist or mists or vapor* or vapour* or fog or fogs or fume or fumes or smoke or smokes or solvents or volatile or chemical* or biological* or SARS or hazardous next substance* or hazardous next material* or dangerous next substance* or asbestos* or particle* or nanoparticle*:ti,ab,kw
#9	#6 OR #7 OR #8
#10	#5 AND #9
#11	work* or occupation* or job or jobs or employee* or organisation* or organization* or laborer* or labourer* or construction next industry or firefight* or miners or fishing or mining or constructors:ti,ab,kw
#12	MeSH descriptor: [Agriculture] explode all trees
#13	MeSH descriptor: [Industry] explode all trees
#14	MeSH descriptor: [Occupational Groups] explode all trees
#15	MeSH descriptor: [Health Occupations] explode all trees
#16	#11 OR #12 OR #13 OR #14 OR #15
#17	#4 AND #16
#18	#10 OR #17
#19	training or program or programs or strategy or strategies or advise* or adviso* or guidelines or behav* or intervention* or attitude* or promot* or safety next culture or safety next awareness or safety next climate or cognitive next model* or maintenance or fit next test* or incentive* or supervis* or positive next reinforcement or social next cognitive or social next model* or health next belief next model* or reasoned next action or frequent next feedback or organizational next polic*:ti,ab,kw
#20	penalty or penalties or enforcement or sanction or sanctions or fines or warning or warnings or feedback or legislation or legislative or regulation* or regulative:ti,ab,kw
#21	#19 OR #20
#22	#18 AND #21 (134) > 60 Central Trials references

Appendix 4. CINAHL search strategy

#	Query	Limiters/Expanders	Last Run Via

(Continued)

S28	S24 AND [embase]/lim NOT [medline]/lim	Search modes - SmartText Searching	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S27	S24 AND [embase]/lim NOT [medline]/lim	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S26	S24 AND [embase]/lim	Search modes - SmartText Searching	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S25	S24 AND [embase]/lim	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S24	S10 AND S15 AND S22	Search modes - SmartText Searching	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S23	S10 AND S15 AND S22	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S22	S17 OR S19 OR S21	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S21	(penalty OR penalties OR enforcement OR sanction OR sanctions OR fines OR warning OR warnings OR feedback OR legislation OR legislative OR regulations OR regulative OR 'labour inspection'):MW,AB,TI	Search modes - SmartText Searching	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S20	(penalty OR penalties OR enforcement OR sanction OR sanctions OR fines OR warning OR warnings OR feedback OR legislation OR legislative OR regulations OR regulative OR 'labour inspection'):MW,AB,TI	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S19	(training OR program OR programs OR strategy OR strategies OR advise* OR adviso* OR guidelines OR guidance OR behav* OR intervention* OR attitude* OR promot* OR 'safety culture' OR 'safety awareness' OR 'safety cli-	Search modes - SmartText Searching	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text

(Continued)

	mate' OR cognitive NEXT/1 model* OR maintenance OR fit NEXT/1 test* OR incentive* OR supervis* OR 'positive reinforcement' OR 'social cognitive' OR social NEXT/1 model* OR 'health belief' NEXT/1 model* OR 'reasoned action' OR 'frequent feedback' OR organizational NEXT/1 polic* OR organisational NEXT/1 polic*):MW,AB,TI		
S18	(training OR program OR programs OR strategy OR strategies OR advise* OR adviso* OR guidelines OR guidance OR behav* OR intervention* OR attitude* OR promot* OR 'safety culture' OR 'safety awareness' OR 'safety climate' OR cognitive NEXT/1 model* OR maintenance OR fit NEXT/1 test* OR incentive* OR supervis* OR 'positive reinforcement' OR 'social cognitive' OR social NEXT/1 model* OR 'health belief' NEXT/1 model* OR 'reasoned action' OR 'frequent feedback' OR organizational NEXT/1 polic* OR organisational NEXT/1 polic*):MW,AB,TI	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S17	'feedback system'/exp OR 'practice guideline'/exp OR 'behavior change'/exp OR 'policy'/de OR 'punishment'/de OR 'law enforcement'/exp	Search modes - SmartText Searching	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S16	'feedback system'/exp OR 'practice guideline'/exp OR 'behavior change'/exp OR 'policy'/de OR 'punishment'/de OR 'law enforcement'/exp	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S15	S12 OR S14	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S14	(work* OR occupation* OR job OR jobs OR employee* OR organisation* OR organization* OR laborer* OR labourer* OR 'construction Industry' OR firefight* OR miners OR fishing OR mining OR constructors OR agriculture OR industry OR 'occupational groups' OR 'health occupations'):MW,AB,TI	Search modes - SmartText Searching	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S13	(work* OR occupation* OR job OR jobs OR employee* OR organisation* OR organization* OR laborer* OR labourer* OR 'construction Industry' OR firefight* OR miners OR fishing OR mining OR constructors OR agriculture OR industry OR 'occupational groups' OR 'health occupations'):MW,AB,TI	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S12	'construction work'/exp OR 'mining'/exp OR 'fishing'/exp OR 'agriculture'/exp OR 'nonmedical occupations'/exp OR 'health care person-	Search modes - SmartText Searching	Interface - EBSCOhost Research Databases Search Screen - Basic Search

(Continued)

	nel'/exp OR 'worker'/de OR 'industry'/exp OR 'work'/exp		Database - CINAHL Plus with Full Text
S11	'construction work'/exp OR 'mining'/exp OR 'fishing'/exp OR 'agriculture'/exp OR 'nonmedical occupations'/exp OR 'health care personnel'/exp OR 'worker'/de OR 'industry'/exp OR 'work'/exp	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S10	S2 OR (S4 AND S9)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S9	S6 OR S8	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S8	(sars OR dust* OR mist OR mists OR vapor* OR vapour* OR fog OR fogs OR fume OR fumes OR smoke OR smokes OR solvents OR volatile OR chemical* OR biological* OR 'hazardous substances' OR 'hazardous material' OR 'dangerous substances' OR asbestos* OR particle* OR nanoparticle* OR gas):MW,AB,TI	Search modes - SmartText Searching	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S7	(sars OR dust* OR mist OR mists OR vapor* OR vapour* OR fog OR fogs OR fume OR fumes OR smoke OR smokes OR solvents OR volatile OR chemical* OR biological* OR 'hazardous substances' OR 'hazardous material' OR 'dangerous substances' OR asbestos* OR particle* OR nanoparticle* OR gas):MW,AB,TI	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S6	'solvent'/exp OR 'dust'/exp OR 'severe acute respiratory syndrome':MW OR 'dangerous goods':SU OR 'volatile organic compound':MW OR asbestos:MW	Search modes - SmartText Searching	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S5	'solvent'/exp OR 'dust'/exp OR 'severe acute respiratory syndrome':MW OR 'dangerous goods':SU OR 'volatile organic compound':MW OR asbestos:MW	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S4	(personal NEXT/2 protect* OR worker* NEAR/2 protect* OR protective NEXT/1 measure*):MW,AB,TI	Search modes - SmartText Searching	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S3	(personal NEXT/2 protect* OR worker* NEAR/2 protect* OR protective NEXT/1 measure*):MW,AB,TI	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Basic Search

(Continued)

			Database - CINAHL Plus with Full Text
S2	(respiratory NEXT/1 protect* OR respirator OR respirators OR 'gas mask'):MW,AB,TI	Search modes - SmartText Searching	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text
S1	(respiratory NEXT/1 protect* OR respirator OR respirators OR 'gas mask'):MW,AB,TI	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - CINAHL Plus with Full Text

#1 =s2	(respiratory NEXT/1 protect* OR respirator OR respirators OR 'gas mask'): MW,AB,TI
#2 =s4	(personal NEXT/2 protect* OR worker* NEAR/2 protect* OR protective NEXT/1 measure*):MW,AB,TI
#3 =S6	'solvent'/exp OR 'dust'/exp OR 'severe acute respiratory syndrome':MW OR 'dangerous goods':SU OR 'volatile organic compound':MW OR asbestos:MW
#4 =S8	(sars OR dust* OR mist OR mists OR vapor* OR vapour* OR fog OR fogs OR fume OR fumes OR smoke OR smokes OR solvents OR volatile OR chemical* OR biological* OR 'hazardous substances' OR 'hazardous material' OR 'dangerous substances' OR asbestos* OR particle* OR nanoparticle* OR gas):MW,AB,TI
#5 =S9	#3 OR #4
#6 = S10	#1 OR (#2 AND #5) S2 OR (S4 AND S9)
#7 =S12	'construction work'/exp OR 'mining'/exp OR 'fishing'/exp OR 'agriculture'/exp OR 'nonmedical occupations'/exp OR 'health care personnel'/exp OR 'worker'/de OR 'industry'/exp OR 'work'/exp (79)
#8 =S14	(work* OR occupation* OR job OR jobs OR employee* OR organisation* OR organization* OR laborer* OR labourer* OR 'construction Industry' OR firefight* OR miners OR fishing OR mining OR constructors OR agriculture OR industry OR 'occupational groups' OR 'health occupations'):MW,AB,TI (25)
#9 =S15	#7 OR #8 (104) S12 OR S14
#10 =S17	'feedback system'/exp OR 'practice guideline'/exp OR 'behavior change'/exp OR 'policy'/de OR 'punishment'/de OR 'law enforcement'/exp (44)
#11 =S19	(training OR program OR programs OR strategy OR strategies OR advise* OR adviso* OR guidelines OR guidance OR behav* OR intervention* OR attitude* OR promot* OR 'safety culture' OR 'safety awareness' OR 'safety climate' OR cognitive NEXT/1 model* OR maintenance OR fit NEXT/1 test* OR incentive* OR supervis* OR 'positive reinforcement' OR 'social cognitive' OR social NEXT/1 model* OR 'health belief' NEXT/1 model* OR 'reasoned action' OR 'frequent feedback' OR organizational NEXT/1 polic* OR organisational NEXT/1 polic*):MW,AB,TI (0)
#12 =S21	(penalty OR penalties OR enforcement OR sanction OR sanctions OR fines OR warning OR warnings OR feedback OR legislation OR legislative OR regulations OR regulative OR 'labour inspection'):MW,AB,TI (10)

(Continued)

#13 =S22	#10 OR #11 OR #12 (54) S17 OR S19 OR S21
#14 =S24	#6 AND #9 AND #13 S10 AND S15 AND S22
#15 =S26	#14 AND [embase]/lim S24 AND [embase]/lim
#16 =S28	#14 AND [embase]/lim NOT [medline]/lim S24 AND [embase]/lim NOT [medline]/lim

CONTRIBUTIONS OF AUTHORS

Pornpun Sakunkoo (PS), David Koh (DK) and Malinee Laopaiboon (ML) drafted the protocol.

All review authors approved the final version of the protocol.

PS, ML, DK, Yen B Luong Thanh (YLT) and Hla Moe (HM) carried out study selection.

PS, YLT, HM, DK and ML carried out data extraction.

ML, YLT carried out data analysis.

YLT, ML and DK wrote the first draft of the review.

YLT, ML and DK revised the draft of the review.

All review authors approved the final version.

DECLARATIONS OF INTEREST

Malinee Laopaiboon: I have received an honorarium from Thailand Research Fund, a non-profit organization, to conduct this Cochrane review.

Bao Yen Luong Thanh: None known.

Pornpun Sakunkoo: None known.

David Koh: None known.

Hla Moe: None known.

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Internal sources

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- Hue University of Medicine and Pharmacy, Hue, Vietnam.

  Salary of Yen B Luong Thanh
- Mandalay University of Medicine, Mandalay, Myanmar.

  Salary of Hla Moe

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DIFFERENCES BETWEEN PROTOCOL AND REVIEW

We have modified the criteria for the assessment of risk of bias for RCTs and CBA studies. We planned to use the standard Cochrane risk of bias tool for RCTs and the Downs 1998 tool for CBA studies. Instead we used the Cochrane risk of bias tool for all studies because the Cochrane risk of bias tool could be adapted to the CBA studies. We did not specify in our protocol when we would consider a study have a high, low or unclear risk of bias overall. We think the distinction makes our GRADE assessment more transparent.

INDEX TERMS

Medical Subject Headings (MeSH)

*Workplace; Controlled Before-After Studies; Farmers; Health Personnel; Health Promotion [*methods]; Interrupted Time Series Analysis; Motivational Interviewing; Occupations; Randomized Controlled Trials as Topic; Respiratory Protective Devices [*statistics & numerical data]

MeSH check words

Humans